April 1991/$3.00

Mobile Radio Technology

The journal of mobile communications technology



Repeater linking, p. 10

Noise figure
Lightning protection

Multiple address systems
Digitally coded squelch
Portable tower

AN INTERTEC PUBLICATION

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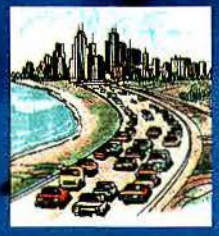


Virtually every cellular system has potentially profitable areas where additional cell sites cannot be economically justified: urban black holes ... tunnels and buildings ... suburban zones on the fringe. Reaching these areas could mean an expanded customer base, increased air-time usage and decreased churn.

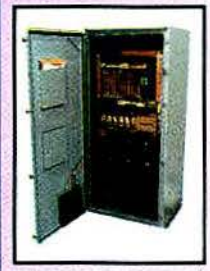


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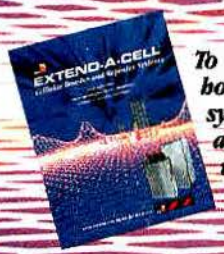
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- C-511 tone (two frequency)
- C-540 tone (coming later...four frequency, 10 line)
- C-581/M tone (eight frequency)

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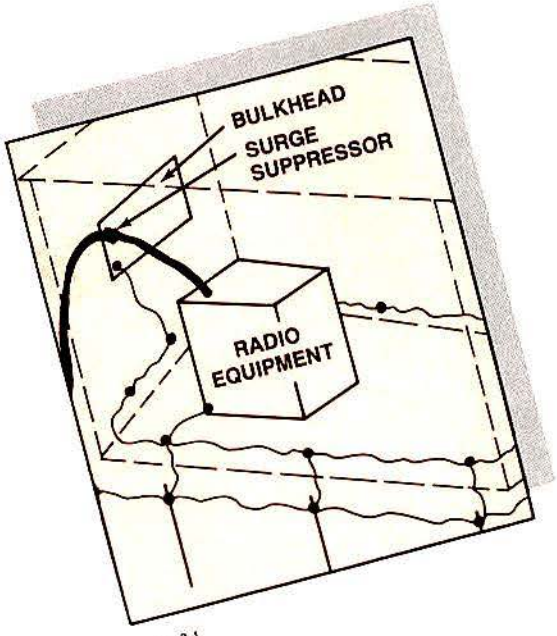
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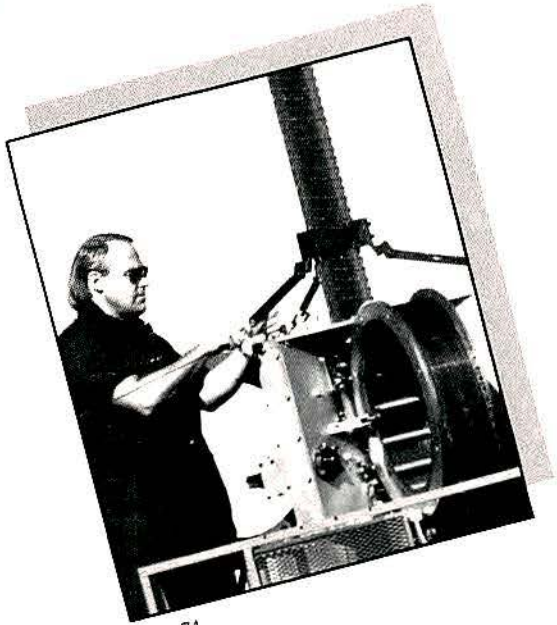
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The Johnsons

Edgar F. Johnson died Feb. 11 at age 91. His wife Ethel died Feb. 13 at age 96.

We are in their debt for the contributions made to the land mobile radio industry by the company they founded and by Edgar as the company's long-time leader.

In 1923, three months after they married, Edgar and Ethel Johnson purchased a supply of electronic components and began selling them through the mail. Shortly thereafter, the company they founded began manufacturing its own components.

Some of land mobile radio's pioneers were introduced to radio communications because they used Johnson components and other parts to build amateur radio stations.

After World War II, the E. F. Johnson Company began manufacturing amateur radio equipment. These Vikings, Navigators, Valiants, Challengers and Rangers, as they were called, introduced another generation to radio communications.

When Class D Citizens Band radio was created in 1958, the company introduced even more individuals and small businesses to mobile communications with its line of low-power Messenger two-way AM radios.

In the 1970s, the company refocused much of its efforts on manufacturing two-way FM land mobile radio equipment, which was added to the product line in 1950. Many of our readers have profited from operating Johnson land mobile radio equipment dealerships.

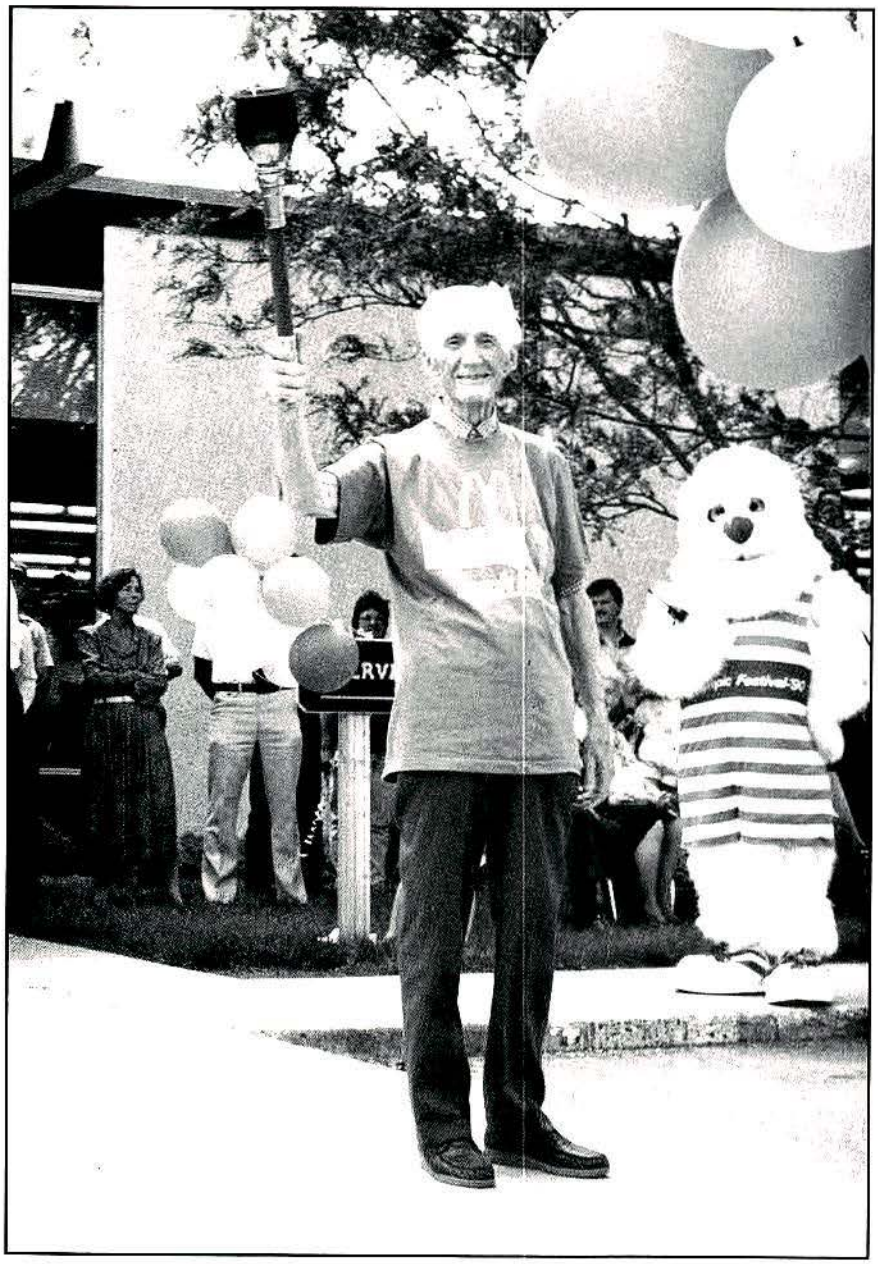
In the 1980s and on into the '90s, other readers made their livelihoods by operating specialized mobile radio (SMR) systems that rely on Johnson LTR repeaters, and mobile and portable radios for their technical infrastructure.

Edgar led the company for 55 years. He retired in 1978 as chairman of the board, though he continued as a board member.

His company was one of the first in Minnesota to offer profit-sharing, and he credited his employees for any success he achieved. "We've had lots of very fine people, and we still do," he said in 1983. "There's never been a time I've not been convinced that is why we do well."

One of the reasons why the land mobile radio industry has done so well is because of the accomplishments of Edgar and Ethel and their associates.

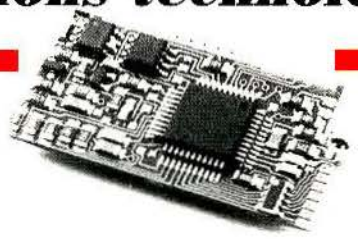
—Don Bishop



Edgar F. Johnson holds the Olympic torch during last year's Olympic Festival '90 event at the E. F. Johnson Company operations center in Waseca, MN.

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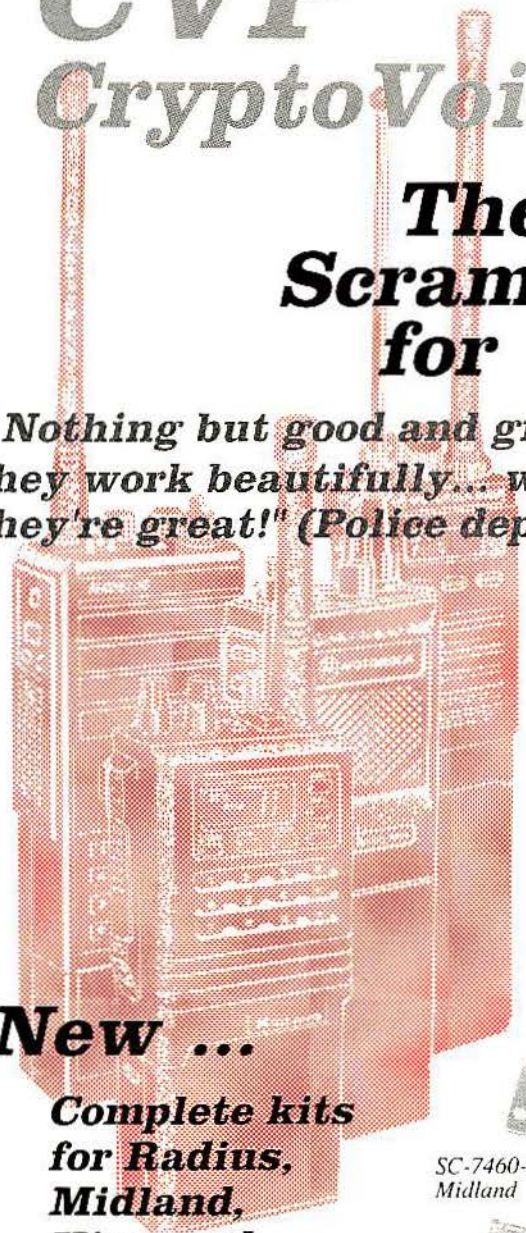


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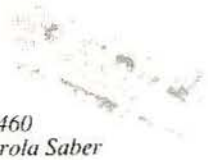
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Letters to the editor

Employment opportunities:

In the same issue that contained the following "Letter to the Editor" complaining about a lack of employment activity in the East were two advertisements from recruiting firms located in the East.

> Is the East Coast dead?
> The only job recruiting advertisements are from west of the Mississippi (or from Florida).
> Name Withheld

Go west, young man. Or 'way south.
—DB

Out of six "help wanted" advertisements in the November issue, there were:

STATE	NUMBER
Pennsylvania	2
California	2
Texas	2

Both of the Pennsylvania firms are recruitment firms offering multiple locations. The others are from direct employers.

Perhaps your advice to this letter-writer should have offered a reference to your "Help Wanted" section instead of a "bromide."

Larry Goldberg
Lawrence Personnel
King of Prussia, PA

Fast Fact Card comments:

The toughest problems on the job are:

- salesmen who do not understand engineers.
- engineers who do not understand salesmen.

Kenneth Huffines
Stone Mountain, GA

Every issue is a real pleasure. I have learned more about communications from your magazine than I have since I purchased my first radios about 11 years ago. Thank you.

The toughest problems facing me on the job are:

- We live in an area with many hills and valleys, as well as high surface temperatures and iron ore deposits.
- Radio privacy is a problem, too—We are on three shared repeaters, and competition is terrible. We are looking at installing scramblers in our transceivers.

Gary S. Stubbs
S P Construction
St. George, UT

The most interesting article in the November 1990 issue is "Digital Coded Squelch: What Makes It Work—Or Fail" by Mark Nadir.

The toughest problems facing me on the job include:

- keeping up to date on frequencies of various agencies, since the use of the spectrum constantly is changing. For example, an agency operating on its assigned frequencies may be there for a

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The journal of mobile communications technology

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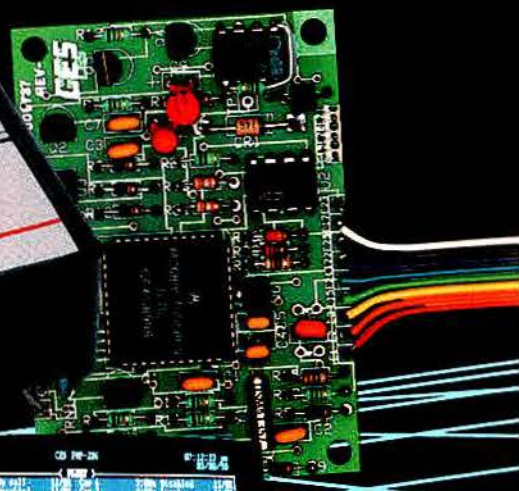
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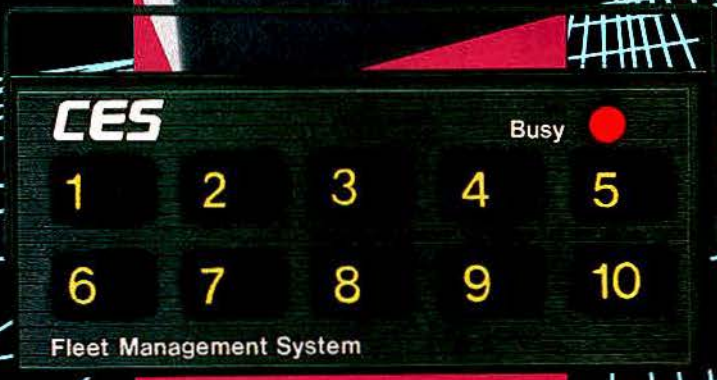
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while, but then the next day you discover they have moved their communications to another set of frequencies.

- making sure everyone knows his or her assignment during severe weather advisories to give adequate warning.

Daniel Bailey
Sabine Pass Storm Spotters
Groves, TX

The toughest problem is that warranties on radios start when the dealer buys them. I cannot have a radio in stock because the warranty runs out day by day. Warranties should start when the radio is sold to the end-user.

Carlos R. Rodriguez
Professional Radiotelephone
Caguas, Puerto Rico

The two toughest problems are:

- retail consumer product stores that sell VHF and UHF radio products.
- the high cost of IMTS radios compared to cellular radios.

Don C. Stiver
Radio Communications Company
Vail, AZ

The November 1990 article "How To Link Mobiles To Form A Repeater" by Carlton L. Tedrick is a waste of paper. If a technician today cannot figure this out for himself, he better get out of two-way.

"Extended Control of Maxtrac Radio" by Harold Kinley is a couple of steps higher than Tedrick's, only because of the references to data and cable length.

Andrew Singer's "Use Downtilt Selectively To Improve System Coverage" is just what I've been looking for. It is the most interesting article in this issue.

The two toughest problems facing me on the job are:

- There are too many unqualified technicians and not enough good technicians.
- With prices going down on equipment, margins keep getting smaller and smaller, making it hard to keep the doors open.

Robby Robinson
AAT Comm
Rosemead, CA

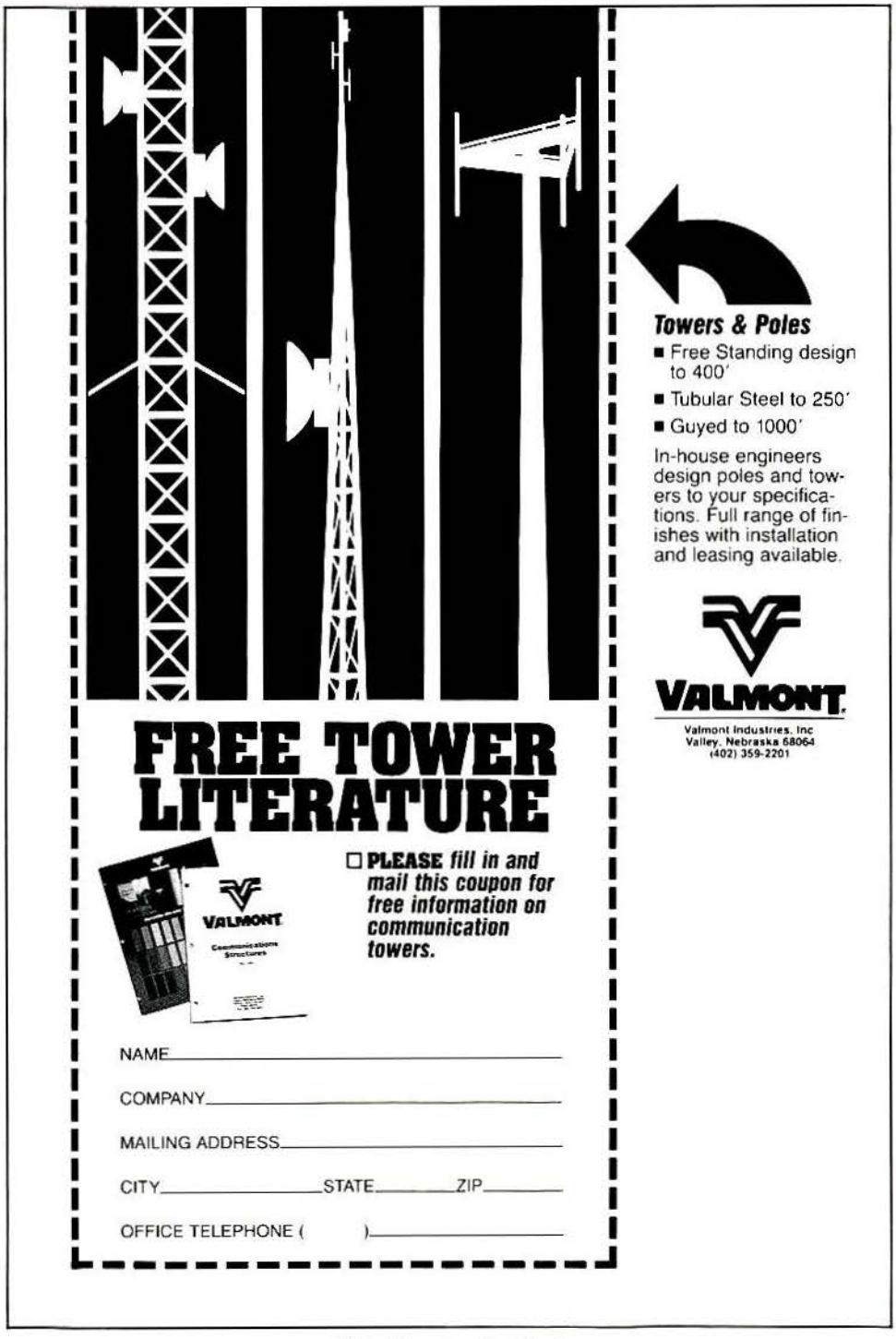
This magazine is the most informative and interesting in the two-way radio field. It has excellent state-of-the-art updates. I'm happy that cellular articles do not clutter up your magazine.

The most interesting article in the July 1990 issue is "How Analog Scrambling Fits Tactical Security Needs" by Don Bishop.

The two toughest problems on the job are:

- finding enough time to service equipment and to spend time with my customers.
- keeping up with licensing requirements.

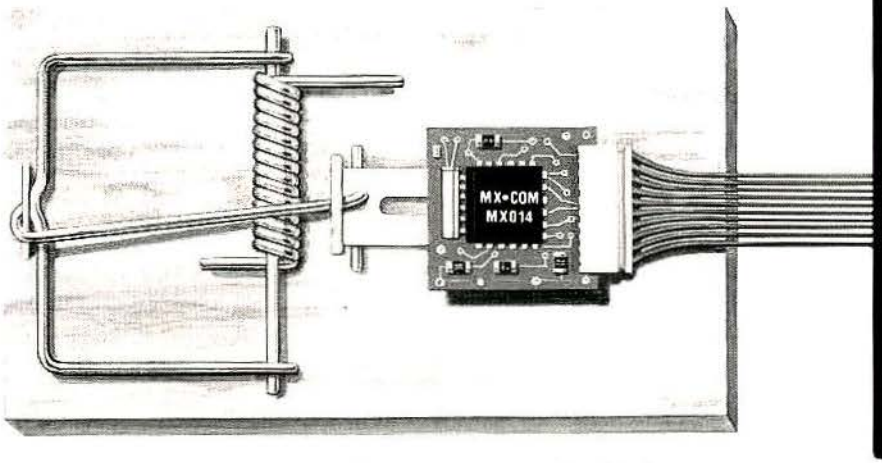
Bruce Resteau
Bartronics
Valparaiso, IN

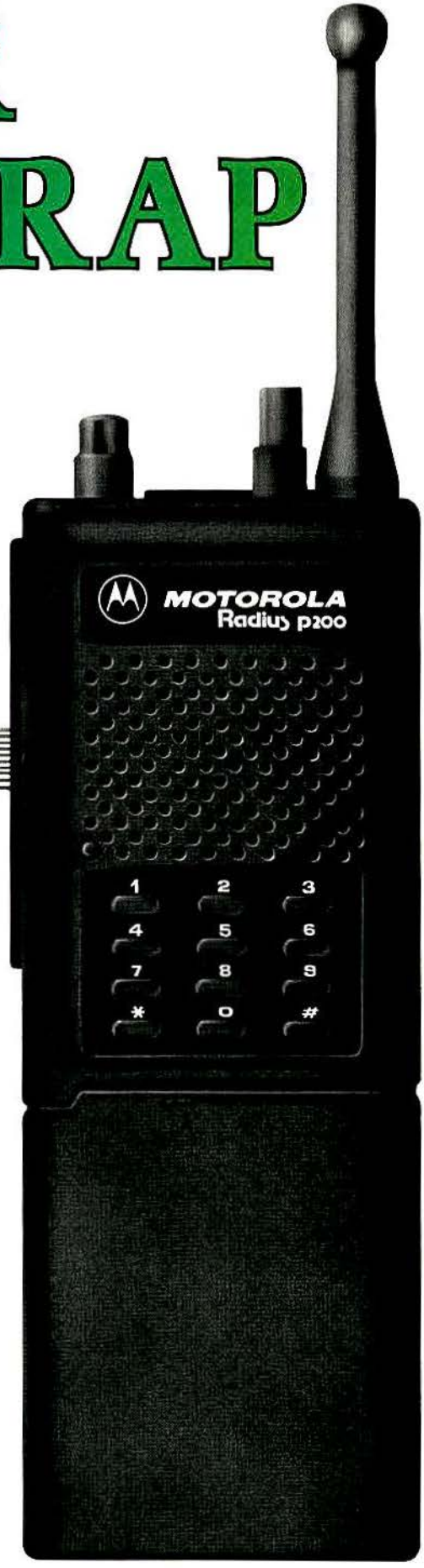


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Circle (9) on Fast Fact Card

Repeater linking solves wide-area coverage problems

Missouri Public Service's new repeater system solves its previous system's 'skip' and noise interference problems. Cross-channel rebroadcasting allows economical use of 450MHz band frequencies.

By René Nix and James Cupp

Wide-area radio communications repeater coverage is being implemented in the 450MHz-to-470MHz band by Missouri Public Service (MPS), a division of Utilicorp United. The finished system will include 15 repeater stations and 32 control stations. It will provide radio communications for approximately 300 mobile and portable radios over a 12,000-square-mile area in Missouri.

Nix is supervisor of telecommunications, Utilicorp United dba Missouri Public Service, Lee's Summit, MO. Cupp is staff communications engineer, Burns & McDonnell Engineering, Kansas City, MO.

The system uses cross-channel rebroadcasting technology as an alternative to simulcasting to solve unique channel access and geographic coverage problems. The completed system will replace MPS' existing VHF lowband mobile radio system.

Lowband problems

For the past 25 years, MPS has operated a single-channel, VHF lowband mobile radio system on 37.54MHz. The system is plagued by all of the typical lowband system problems. Long-range "skip" interference and noise from power lines and precipitation are a continuous annoyance, and they often make communications difficult.

Because the lowband system is simplex, mobile-to-mobile coverage is poor. The result is channel contention problems, particularly when storms and widespread system outages result in high communications activity.

In 1987, MPS retained Burns & McDonnell Engineering to perform a feasibility study to identify the best solution to the mobile communications problems. The following criteria were set:

(1) Each of MPS' nine operating districts must have its own private communications channel that would not be subject to interference from other MPS districts or outside agencies.

(2) MPS must have the ability to "merge" or "link" multiple districts' communications channels together for centralized, after-hours crew dispatching.

(3) The system must provide reliable portable radio coverage for transmission line foot patrols and similar operations.

(4) The current "skip," noise and channel contention problems must be remedied.

(5) The use of leased telephone lines must be reduced or eliminated to increase circuit reliability and economy.

Options considered

It soon became clear that keeping the system in the VHF lowband would not meet the criteria. A new system in a higher frequency band was indicated.

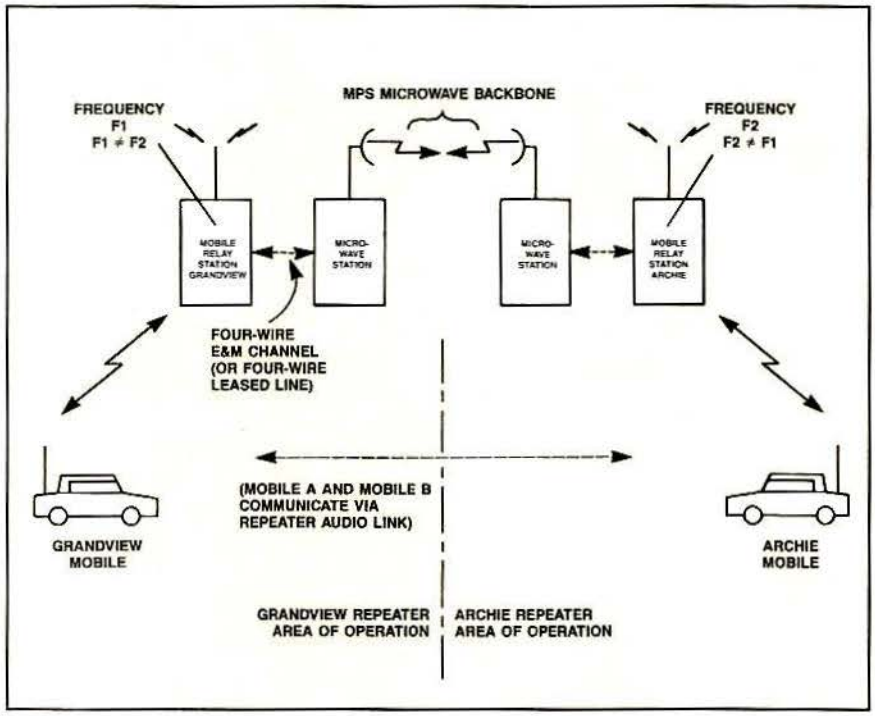


Figure 1. Repeaters operate at different frequencies but communicate over the existing microwave system by using cross-channel rebroadcast technology that links the repeaters.

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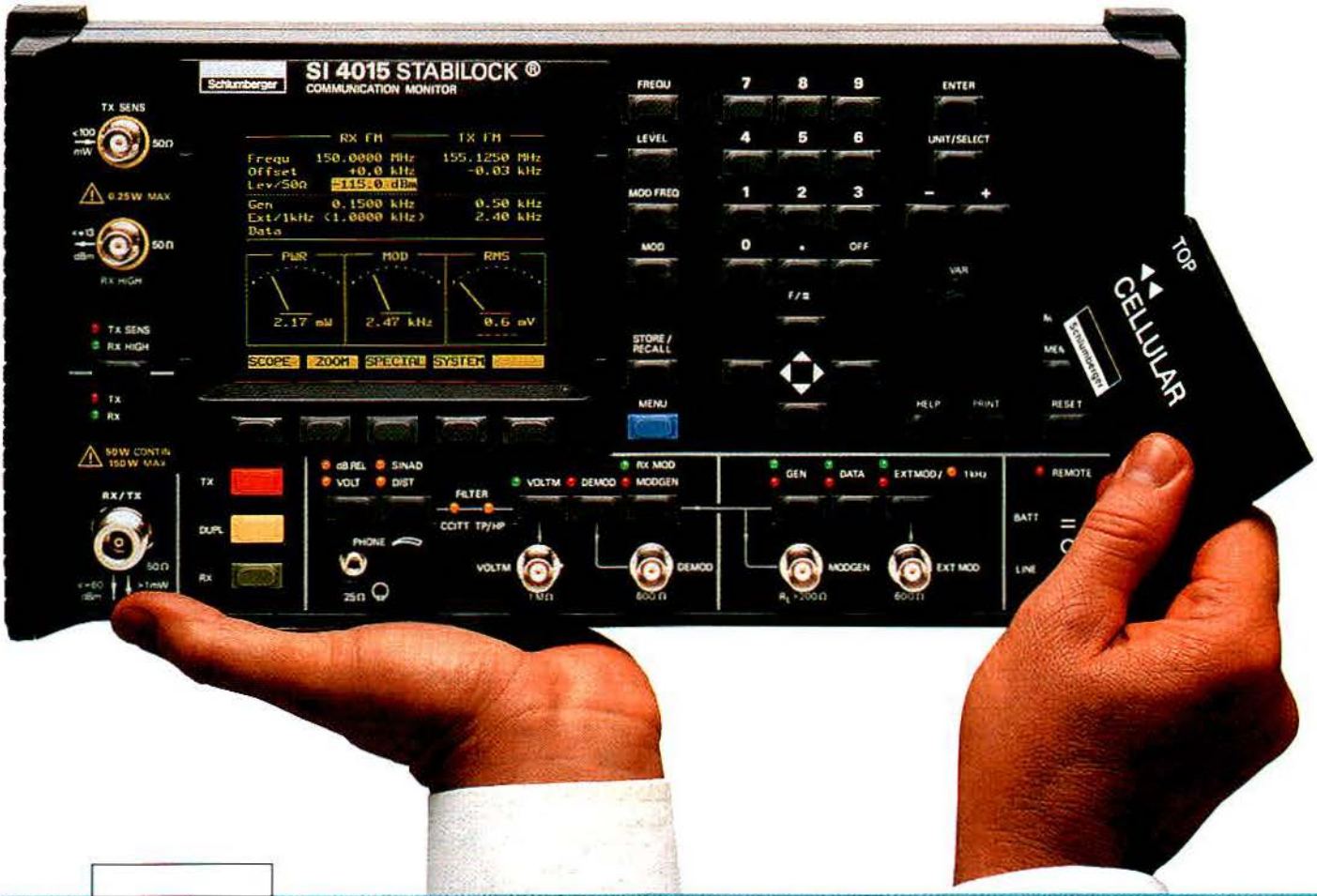
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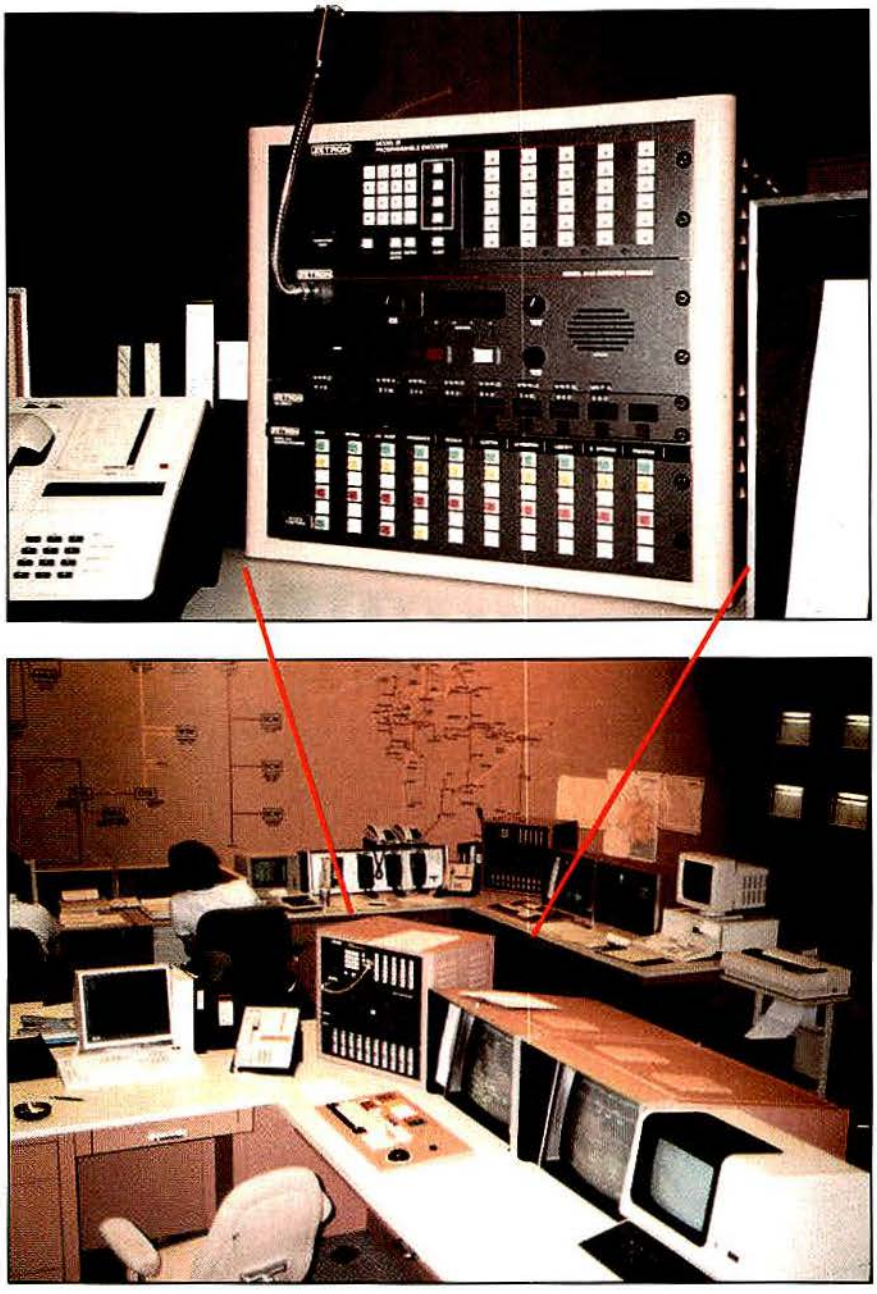
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In the MPS system operations control room, two multichannel control consoles are put to use.

An extensive frequency search was conducted to identify what, if any, spectrum was available for licensing. Only two bands held promise: 450MHz and 860MHz. The industrial 860MHz spectrum virtually was unused throughout MPS' service territory. The 450MHz spectrum was quite congested in MPS' metropolitan districts, including portions of the greater Kansas City area, but it appeared sufficient spectrum was available to meet the objective.

The decision was made to proceed with a 450MHz repeater system instead of 860MHz, for several reasons.

First, MPS mobile units are too few and are separated widely geographically, making an 860MHz trunked system impractical. Conventional (non-trunked) equipment was virtually unavailable at the time the study was made.

Second, MPS planned to use its existing microwave towers to hold the new repeater system's antennas. The towers, ranging from 150 feet to 300 feet tall, could not be expected to offer enough coverage at 860MHz, especially in the rough, forested terrain of the Missouri Ozark regions.

Third, 860MHz equipment was priced considerably higher than equivalent 450MHz equipment.

Design approach

Repeater sites initially were selected with the help of crude radio horizon calculations. The calculations indicated which MPS microwave towers were likely to provide the best overall coverage of a particular operating district.

Detailed, computer-generated propagation analyses were obtained from Comsearch, Richardson, TX. These analyses allowed the engineering staff to identify potential problem areas with respect to geographic coverage. Actual field testing was conducted to confirm the coverage.

Licensing

Once path design and field testing were complete, MPS moved quickly to obtain frequency coordination and radio licenses. The process revealed several errors in the FCC public-use database. Some frequencies the database showed as unused in the Kansas City metropolitan area actually were licensed and in use.

Because of the database errors, MPS was forced to negotiate sharing agreements with several other utilities in the area and to conduct additional field tests.

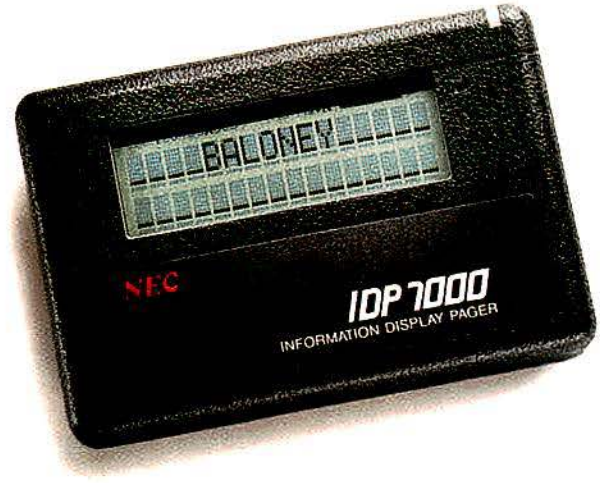
In addition, an FCC rule waiver was required to use a certain frequency pair at a particular site. Keller & Heckman, a Washington, DC, law firm, assisted in obtaining the waiver.

The combination of these difficulties extended the frequency coordination and licensing process for more than 18 months. Eventually, enough frequencies were licensed to allow the system to be implemented.

Procurement

Because of the specialized linking and control features, a request for technical proposals was issued to qualify vendors prior to issuing bid documents. Only vendors whose technical proposals indicated a clear understanding of the system requirements, as well as the ability to provide the system, were placed on the final bid list.

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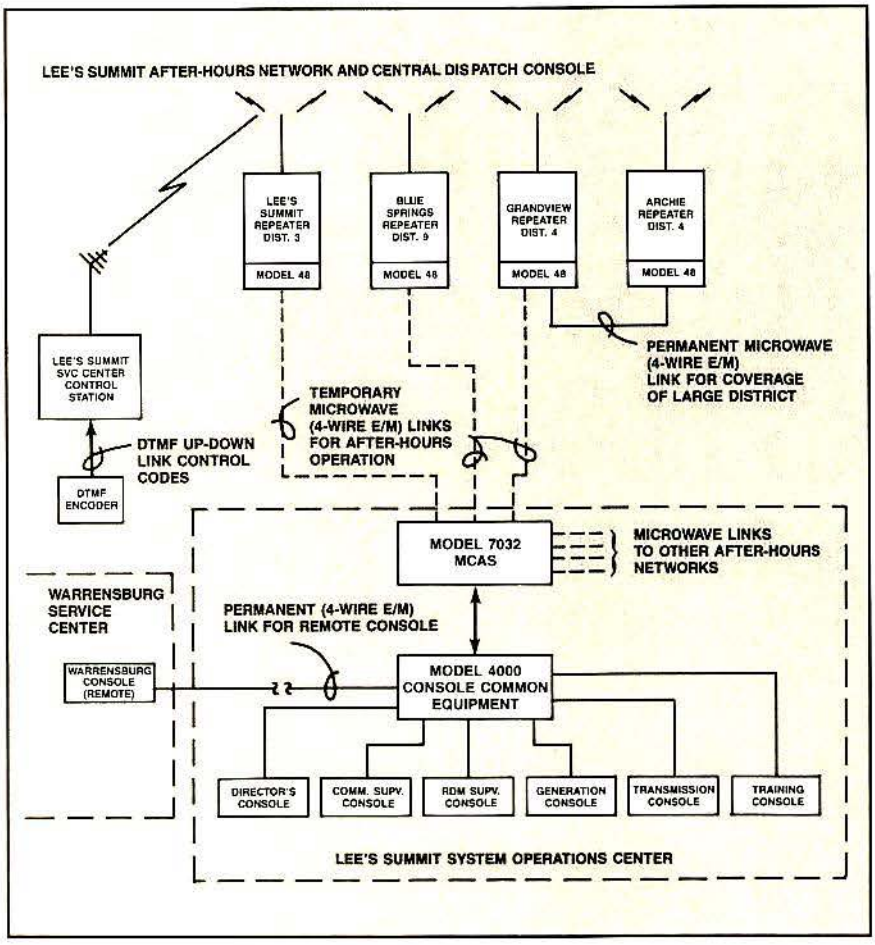
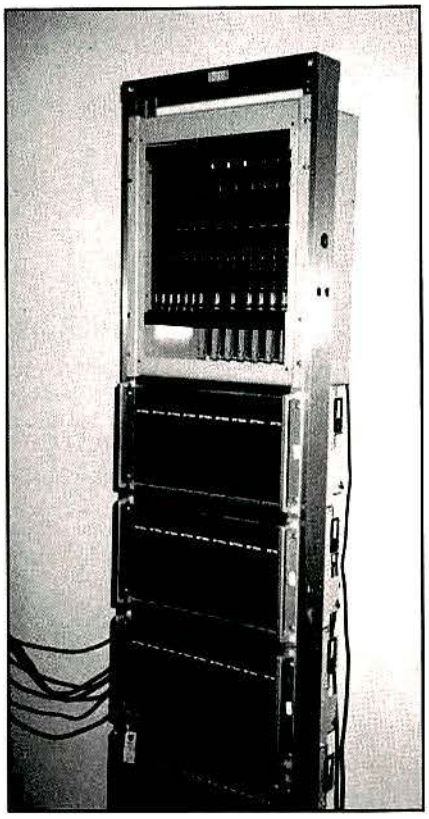
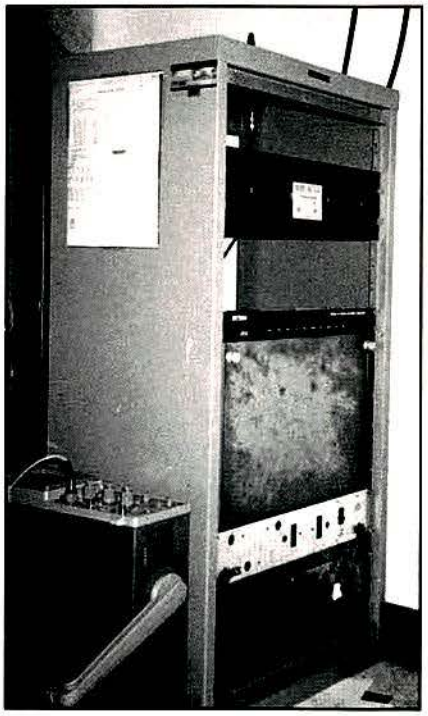


Figure 2. Block diagram of the new communication system configuration at the Missouri Public Service Lee's Summit System Operations Center shows how the repeaters are accessed. The system includes the after-hours network and central dispatch console.



The model 4000 console common electronics bank occupies the top rack space with the model 7032 multichannel access system below.



A typical repeater at Grandview includes a power supply, transceiver assembly, model 48 repeater manager and duplexer.

Bids were received and evaluated, and Ericsson GE Mobile Communications (formerly General Electric Mobile Communications), Lynchburg, VA, was awarded the contract to furnish and install the system in three phases and two years.

Phase 1, which includes all of MPS' Kansas City metropolitan and suburban operating districts, was completed in April 1990. Phase 2 was completed in February 1991. Phase 3 is set for completion in July 1991.

System features

The UHF system's unique feature is its ability to link repeater audio signals via the microwave system. Four-wire leased telephone lines can link repeaters that are not placed along the microwave route.

The linking feature, which is more appropriately reffered to as "cross-channel rebroadcasting," resembles simulcasting because audio received by any one repeater on the link is transmitted by all repeaters on the link simultaneously. The simultaneous transmission allows mobile and control stations to communicate, even though they may be in different repeater coverage zones. (See Figure 1 on page 10.)

An important distinction between cross-channel rebroadcasting and simulcasting: Unlike simulcasting, cross-channel rebroadcasting uses different radio frequencies at each repeater site on the network. This method eliminates the need for expensive audio delay processing equipment and highly stable transmitter oscillators that would be needed for simulcasting.

Cross-channel rebroadcasting requires mobile operators to know each repeater's approximate coverage zone so they can switch their radios manually to

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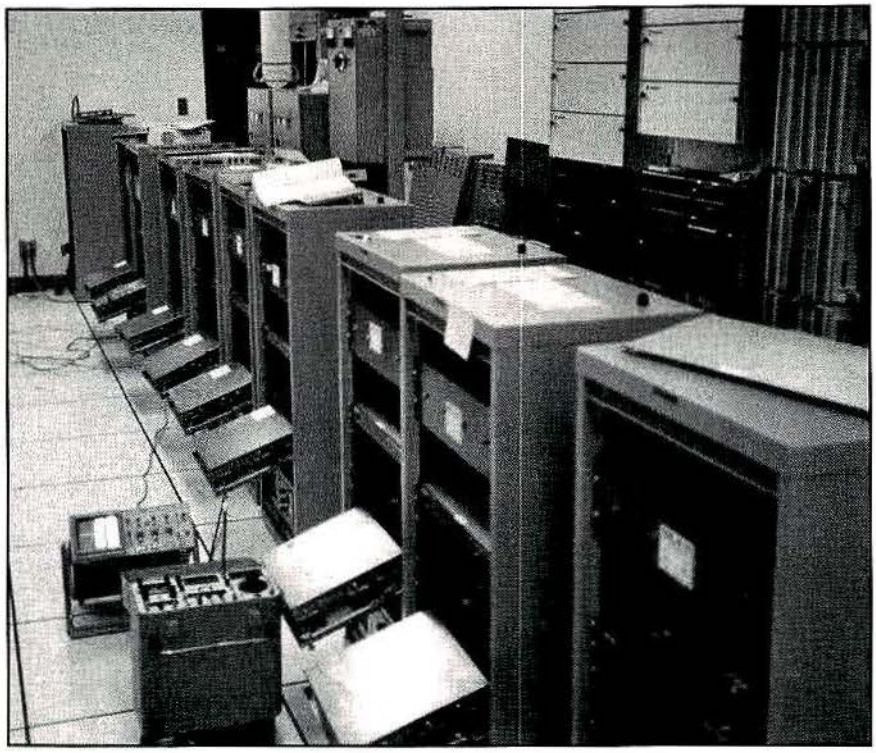
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System repeaters were assembled for checkout prior to field installation.

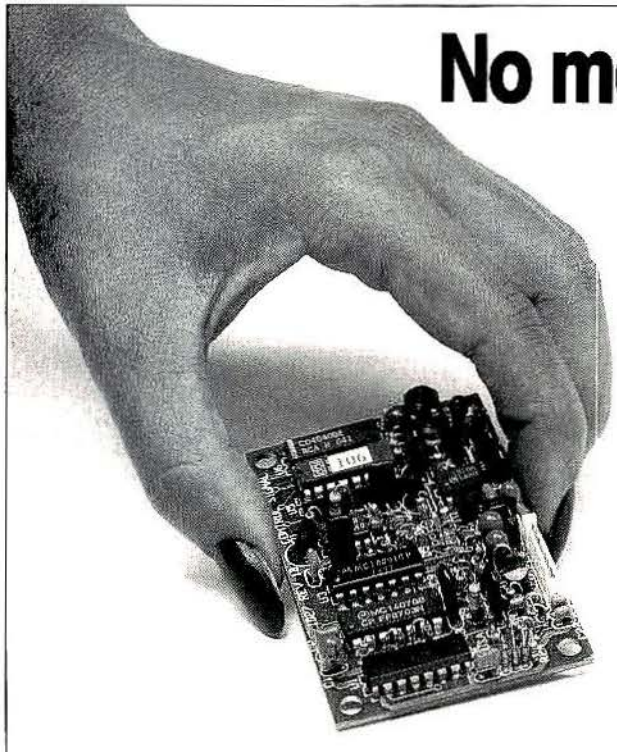
the right channel as they move beyond one repeater's range and into another's.

Rebroadcasting applications

MPS uses cross-channel rebroadcasting for two basic applications.

First, several permanent links have been established to cover large rural districts where a single repeater's coverage is inadequate.

Second, temporary links are established daily to merge multiple districts' repeater systems to establish an after-hours network. The overall network actually is made up of three separate after-hours networks. Each individual network consists of four-to-seven repeaters. The after-hours network allows multiple districts to be dispatched from a single control station during evening and nighttime hours. During business hours, the network is disabled to allow each district to communicate independently. Activating the link is done via dual-tone, multiple-frequency (DTMF) control tones transmitted over the radio channel from a control station in the dis-



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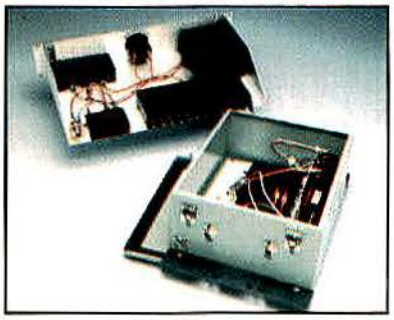


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trict responsible for after-hours dispatching.

The cross-channel rebroadcasting equipment includes Zetron's model 48 repeater manager installed in each repeater and used with a model 7032 central control terminal. (See photo on page 14.)

Model 48s have stand-alone cross-channel rebroadcasting capability. Model 7032 central control terminal allows a central dispatch console at the MPS Lee's Summit System Operations Center to access the link network.

The multichannel series 4000 console system was supplied by the same company. Figure 2 on page 14 is a simplified block diagram of the basic configuration for one of the three after-hours networks.

The equipment uses frequency-shift keying (FSK) in-band data bursts to key the control and continuous-tone coded squelch system (CTCSS) tone selection among the repeaters. The data bursts take the place of VOX operation, which commonly had been used in similar applications.

In addition to providing cross-channel rebroadcasting, Model 48 acts as a tone panel and telephone interconnect. Its 1.75-inches-high rack-mount configuration conserves space in the repeater cabinet. (See photo on page 14.)

Prior to being installed, the repeater backbone equipment was assembled on the test floor for final testing and function verification. (See photo on page 16.) This approach allowed the software modification and hardware troubleshooting before the equipment was dispersed to various field locations.

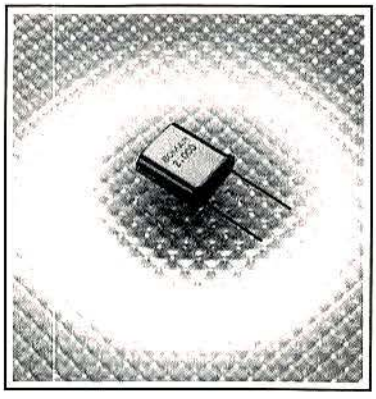


An existing MPS microwave tower in Lee's Summit, MO, supports one of the new repeater antennas.

In addition to cross-channel rebroadcasting, the MPS system includes automatic number identification (ANI), DTMF selective signaling and half-duplex telephone interconnect. The radio equipment includes GE Mastr II repeaters and GE Rangr mobile units and control stations.

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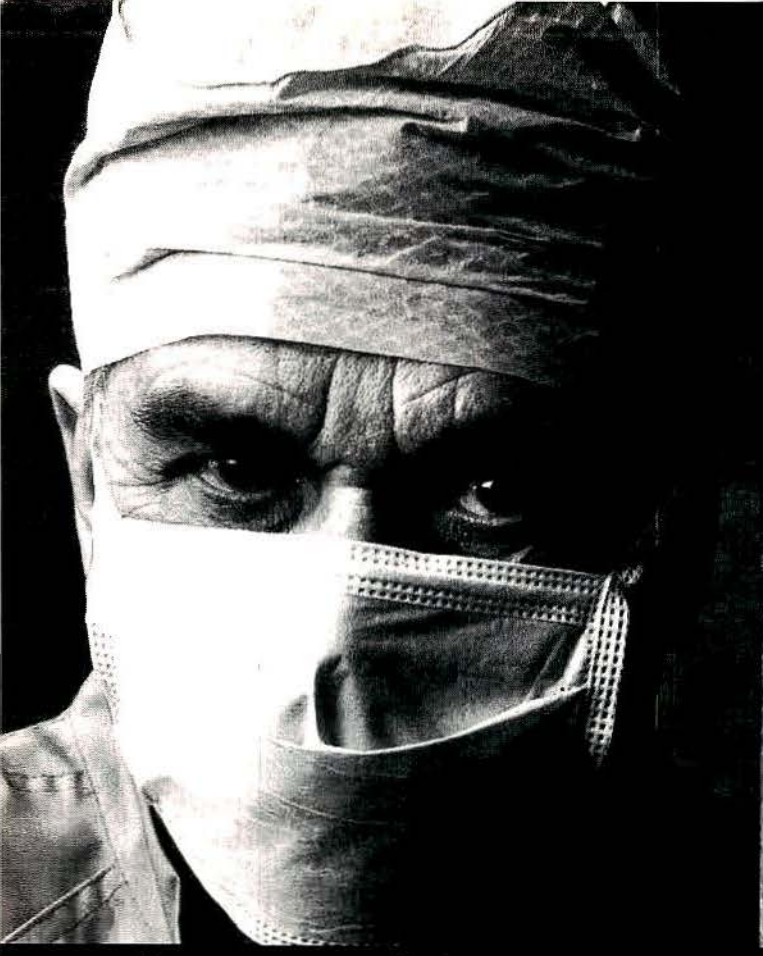
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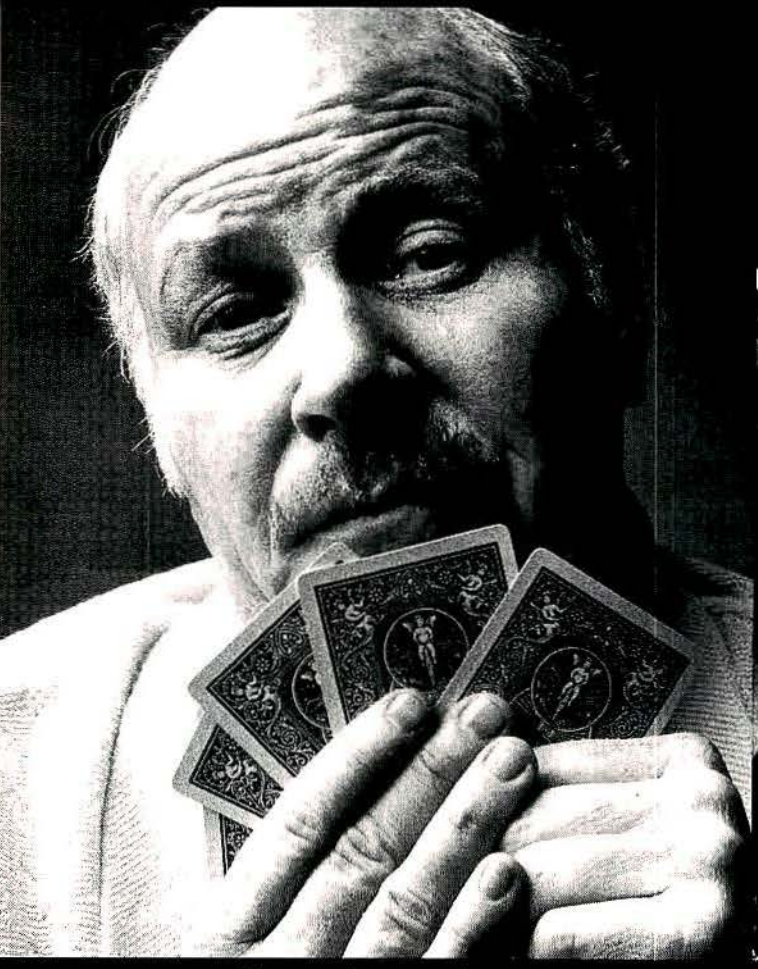
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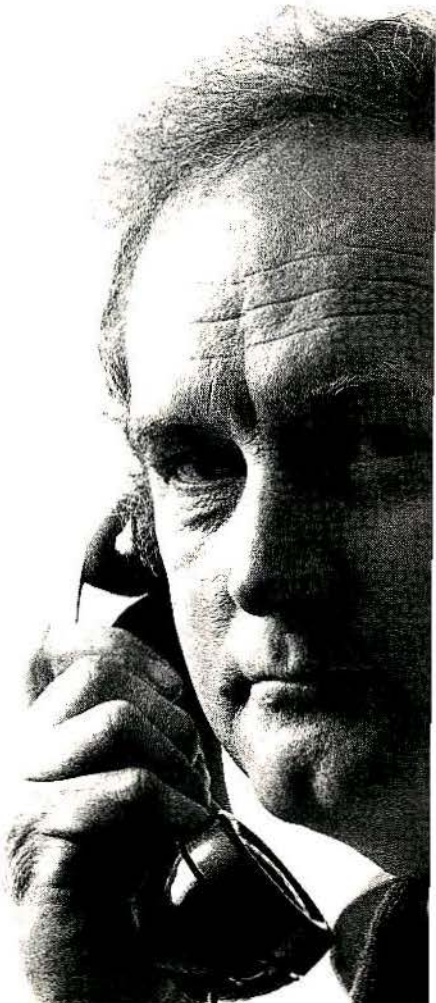
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Improving 'noise figure' gets coverage in shape

Improving your system's ability to receive signals from portable transceivers and from mobiles in fringe areas begins at the antenna. Some systems benefit from the use of an amplifier at or near the antenna.

By Andrew Singer

The lower a radio communications system's noise figure is, the better the system picks up weak signals. A system with a low noise figure is able to receive signals better from portable transceivers used in concrete-and-steel buildings, basements and other difficult-to-reach areas, all other things being equal. The system is able to receive signals from mobile units in fringe areas better.

A high-gain antenna; a towertop amplifier; a preselector filter; low-loss coaxial cable; or a combination may improve the noise figure. Improving the noise figure performance involves increasing the signal-to-noise ratio, raising the third-order intercept point and reducing attenuation.

The signal-to-noise ratio can be improved with gain antennas and towertop amplifiers. The object is to raise the signal as much as possible without raising the noise.

(1) *Antenna gain*—Some antennas discriminate better than others against noise and signals from unwanted directions by focusing on desired signals. For omnidirectional antennas, this discrimination usually is expressed as *gain*. Up to a point, the higher the gain, the more the antenna boosts the wanted signal and reduces noise reception in unwanted directions. At some point, higher gain may cause the antenna to focus too tightly to offer the desired coverage.

Antenna gain improves the *signal-to-noise* ratio, meaning the signal is made that much stronger than noise. The signal picked up by the antenna travels through cables, amplifiers and receivers that *add* noise, degrading the noise figure. The more the antenna intensifies signals it picks up, the better the receiver can reproduce weak signals.

(2) *Towertop amplifier gain*—An amplifier placed at or near the antenna boosts signals before they are fed through coaxial cable connecting the antenna with radio equipment. If the cable loss is high, the amplifier may boost weak signals enough to reach the receiver, where without the amplifier, the sig-

Singer is senior applications engineer at Sinclair Radio Laboratories, Tonawanda, NY.

Improving performance

Improving radio communications system performance starts at the antenna and continues along the signal path toward the receiver.

Antenna

Select an antenna that reduces noise pickup and increases the received signal strength.

***Omnidirectional*—Use an antenna with as much gain as is practical, consistent with coverage requirements.**
***Directional*—If you do not need coverage in all directions, select a directional antenna. It will reduce noise pickup from directions that are of no use.**

Towertop amplifier

Towertop amplifier performance represents a trade-off between:

***Noise figure*—The lower the noise figure, the better the amplifier output's signal-to-noise ratio.**
***Third-order intercept point*—The higher the third-order intercept point, the less likely the amplifier is to generate intermodulation interference that can block the desired signal. Generally, the higher the third-order intercept point, the higher the noise figure, so amplifier selection represents a balance between the two.**

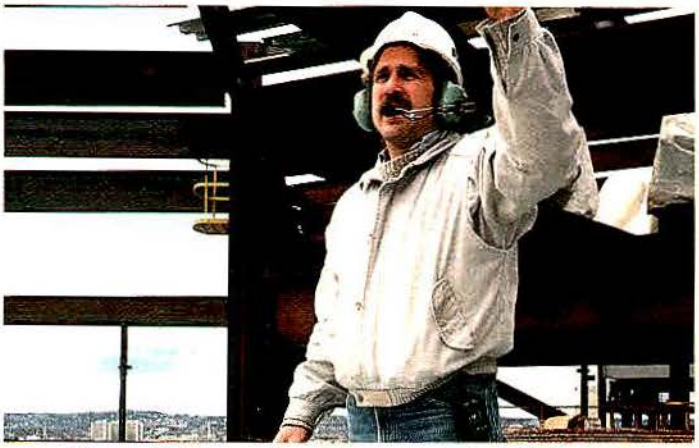
Preselector filter

A preselector filter placed ahead of the towertop amplifier may allow the use of an amplifier with the lowest noise figure. The filter reduces unwanted strong signals that may generate intermodulation interference in an amplifier with a low noise figure and its corresponding low third-order intercept point.

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nals would be lost in the noise.

(3) *Towertop amplifier intermod*—In the presence of strong signals on most any frequency, amplifiers sometimes generate intermodulation interference that blocks the signals they are intended to amplify. Amplifiers with the greatest resistance to intermod have the highest *third-order intercept point.*

Amplifiers with the lowest noise figure usually have the lowest third-order intercept point. To be useful at sites near powerful transmitters, such amplifiers may have to be protected with preselector filters that attenuate off-channel signals. Unfortunately, the filters attenuate the desired signal a little, too, so they reduce the signal-to-noise ratio at the same time the amplifier improves it. The filtering requirement may make it impossible to use a towertop amplifier to *full* benefit at a site engulfed by powerful, undesired signals, but a worthwhile reduction in noise figure normally is possible.

Matching the right amplifier to a specific application involves a trade-off: Enough gain and a low enough noise figure to be beneficial, but a third-order intercept point high enough so amplifier-generated intermodulation interference does not result.

(4) *Coaxial cable*—Upgrading the coaxial cable to a low-loss cable helps to keep signals from being weakened too much for the receiver to hear them.

The stronger the signal is compared to the noise—the signal-to-noise ratio—the better the reception.

Noise and your system

Any radio system contains noise. Noise is introduced to the system by antennas, amplifiers and interfering signals. Noise obscures the desired signal, so the higher the noise, the less the system is able to hear a weak signal.

When a radio signal reaches an antenna, it causes a minute electrical current to flow. The current flows from the antenna to the coaxial cable and into the receiver circuits.

Atomic particles—electrons—carry the electrical current. At ordinary temperatures, electrons have a random motion that causes a small current flow, too. When amplified by a receiver, random-motion current is heard as background noise called *thermal noise.* The higher the temperature of the various components in the system, the higher the thermal noise. All amplifiers, no matter how well they are designed, introduce noise into the system. Every conductor contributes thermal noise.

Signal-to-noise ratio

The stronger the signal is compared to the noise—the signal-to-noise ratio—the better the reception. The higher the signal-to-noise ratio at the antenna, the better the system receives weak signals.

Noise contributed by any component or stage of the system is called the *noise factor* or *noise figure.*

Which amplifier is best?

Amplifiers built for placement at or near the antenna (towertop amplifiers) normally use bipolar transistors or galenium arsenide field-effect transistors (GaAs FETs).

Generally, GaAs FET devices have lower noise figures than bipolar devices. GaAs FET amplifier noise figures usually range from 0.5dB to 2dB. Bipolar amplifier noise figures normally range from 3dB to 4dB. The lowest noise figure is desirable because it contributes the least noise to the signal-to-noise ratio.

But devices with the lowest noise figure generally have the lowest third-order intercept point, which means they are more likely to generate intermodulation interference in the presence of strong signals. For GaAs FET amplifiers, the third-order intercept points usually range from +20dBm to +25dBm, but some may be higher. For bipolar amplifiers, the third-order intercept points normally range from +25dBm to +40dBm, depending on the frequency range. The higher intercept points usually are obtained at the lower frequencies.

Thus, choosing the right amplifier is a trade-off between noise figure and third-order intercept point characteristics. A compromise may involve placing a GaAs FET amplifier at the antenna and a bipolar amplifier in the base unit.

Some manufacturers have computer software that can be used to make "what if?" calculations as you substitute system components to show the gain, noise figure and intercept point for your system. Using the software, you can change components to tailor a system to fit your requirements.

In environments with high RF fields, such as in many suburban and most urban areas, it almost is a requirement to place a preselector filter ahead of the amplifier. Even though a preselector filter may add 1.5dB to 2dB to the noise figure, it benefits a system that otherwise could be overloaded.

A lower noise figure does not always improve reception. Reducing the system noise figure improves weak-signal reception when the receiving antenna is in an environment of thermal noise, but not when it is in an environment of man-made noise.

In urban areas, noise from vehicle ignition systems, FM and TV broadcast transmitters and co-located radio communications base station transmitters on congested sites may raise the site noise level higher than the thermal noise level by several decibels. In some cases, the man-made noise may exceed the thermal noise by 20dB to 30dB.

Under these conditions, reducing the system noise figure does not substantially improve radio communications performance.

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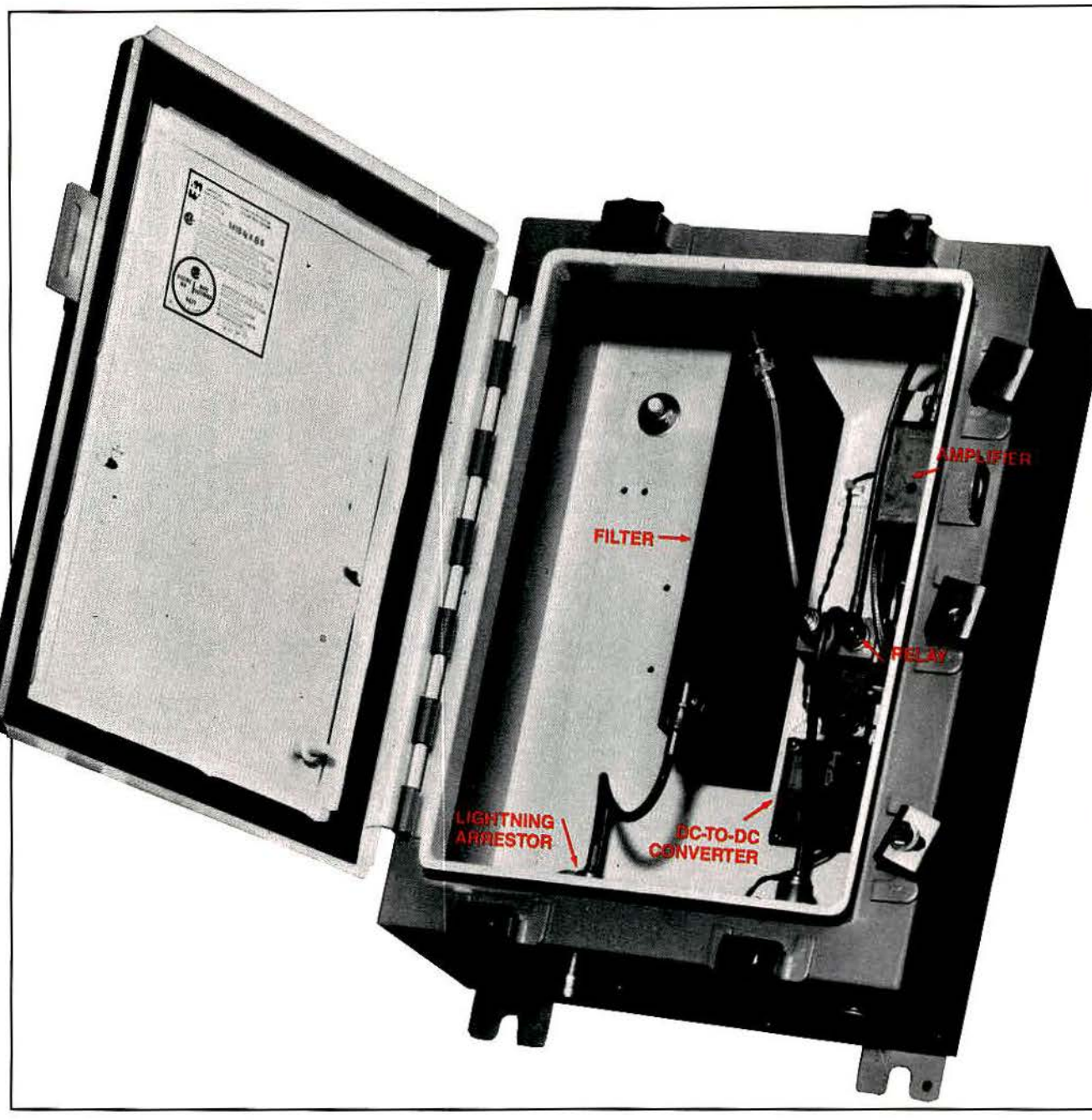


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This weatherproof box encloses a preselector filter and a towertop amplifier for mounting on a tower or other location that is exposed to the elements.

• *Noise factor*—The noise factor, F, is defined as the ratio of the signal-to-noise ratio at the input of a stage to the signal-to-noise ratio at the output of a stage:

$$F = (S_i/N_i)/(S_o/N_o)$$

• *Noise figure*—The noise factor expression can be difficult to work with. Calculations are easier with the noise figure, F_N, which simply is the noise factor expressed in decibels:

$$F_N = 10\log(S_i/N_i) - 10\log(S_o/N_o)$$

This expression makes it easy to see that the noise figure simply is the amount, in decibels, that the signal-to-noise ratio is degraded as the signal passes through the stage.

For example, if the signal-to-noise ratio at the amplifier input were 45dB and the amplifier has a noise figure of 5dB, the signal-to-noise ratio at the amplifier output would be 40dB.

An ideal receiver would have a noise figure of 0dB, which would cause no degradation of the signal-to-noise ratio.

For each example, a typical receiver effective noise bandwidth of 10kHz is assumed (an effective noise power of −134dBm).

You can see that the system's signal-to-noise ratio can be no better than the signal-to-noise ratio at the antenna, be-

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What often motivates authors includes:

- increased visibility that may lead to advancement within their companies.
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- product awareness, especially for technology and functions beyond what might be revealed by advertising.

Experience makes good articles

Technicians and engineers who have solved a particular problem or who have developed a new technology or technique are well equipped to tell a story that would interest our readers. Usually, the more practical the idea or method, the better the article.

Although explanations of the latest developments make good articles, so do tutorials that explain basic subjects. Reviews of digital signal processing, microwave system design and software have proven popular, for example. "Big" subjects can be handled with a series of articles. "How-to" descriptions are well received.

Editorial assistance

Some articles arrive ready to be published. If an article is not quite ready for publication, our editors can make the necessary modifications, sometimes requiring only a telephone conversation with the author. If for some reason an article must be returned, suggestions are included for revisions that would make it ready to publish. A set of guidelines for writing is available for the asking.

Artists are available to prepare artwork, such as drawings and graphs. Sketches submitted can be redrawn for illustrations. Camera-ready artwork is welcome, too.

Color photos are considered for use on the cover; slides and transparencies work best as cover illustrations. Otherwise, photos may be submitted as slides, transparencies or prints. If you would like to submit a picture as a possible cover illustration, we recommend you talk with an editor to increase your chances of obtaining a usable photo on the first try.

We have editors who love to help people prepare articles for the magazine. If you are undecided whether your topic might be suitable or if you need help at any stage in the writing process, please call. We would like to hear from you.

Call or write:
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Mobile Radio Technology
P.O. Box 12901
Overland Park, KS 66212
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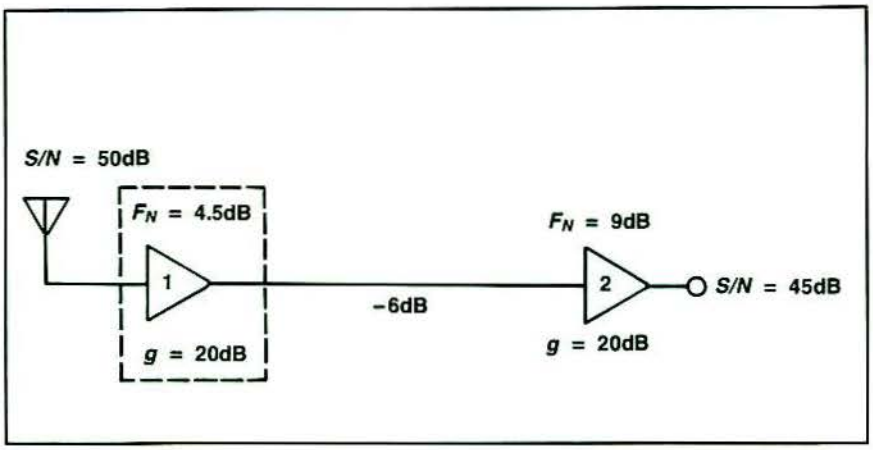


Figure 4. The 6dB cable loss in Figure 3's example may be overcome with the use of a towertop amplifier. The net gain of the first amplifier equals the gain of the amplifier in decibels, less the cable loss.

$= 2.8 + (7.9 - 1)/100$

$= 2.9$

$F_N = 10\log(2.9) = 4.6\text{dB}$

$S/N = 50 - 6 - 4.6 = 39.4\text{dB}$

These calculations show that the contribution of the second stage to the total system noise figure is minimal. Its contribution decreases as the first-stage gain increases. For practical purposes, if the first-stage gain is 15dB or more, the noise contribution of any additional stages can be ignored.

The 6dB loss in the signal-to-noise ratio caused by the cable in the last example considerably degrades system performance. To overcome this loss, assume the use of a towertop amplifier, as shown in Figure 4 above. The net gain of the first amplifier equals the gain of the amplifier in decibels, less the cable loss.

Once again, first convert the noise figures to noise factors to calculate the total system noise figure. Then calculate the output signal-to-noise ratio.

$F_1 = \log^{-1}(4.5/10) = 2.8$

$F_2 = \log^{-1}(9/10) = 7.9$

F_{tot}

$= F_1 + (F_2 - 1)/g_1$

$= 2.8 + (31.6 - 1)/100$

$= 2.8 + 0.3$

$= 3.1$

$F_N = 10\log(3.1) = 4.9$

$S/N = 50 - 4.9 = 45.1\text{dB}$

where

F_1 = Noise factor of the first stage

F_2 = Noise factor of the second stage

g_1 = Net gain of the first stage (amplifier gain − cable loss)

This calculation shows that, although the second amplifier contributes a small amount of noise, the pre-amplifier overall is beneficial because it makes up for the signal that otherwise would be lost in the cable.

Three steps may be taken to improve the system's signal-to-noise ratio:

(1) The signal-to-noise ratio can be no better at the output than it is at the input, so using an antenna with the highest practical gain is recommended.

(2) The system signal-to-noise ratio is controlled by the first amplifier in the system. Thus, system performance is improved through the use of a first-stage amplifier with as low of a noise figure as possible.

(3) Placing the first amplifier stage as close to the antenna as possible avoids much of the signal-to-noise ratio loss caused by long runs of coaxial cable, thus improving the system performance.

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Protective measures stop lightning damage

Experience with multiple sites subject to lightning damage led a gas distribution company to use common grounding beds and precast concrete shelters to avoid equipment loss and radio communications downtime.

By Arnold Domanus Jr.

Protecting radio communications sites from lightning-induced electrical surge currents improves safety conditions and reduces maintenance expenses. It can prevent the loss of communications, which is important to various users for different reasons:

- For radio communications service-providers, uninterrupted service improves customer satisfaction and sustains revenue flow.
- For industrial and commercial enterprises, uninterrupted radio communication sustains productivity and competitive advantages.
- For public safety agencies, radio communication supports safety-of-life and law enforcement services.

Northern Illinois Gas (NI-Gas), as an industrial radio communications user, protects its radio facilities by equalizing the electrical potential that exists among equipment and towers during lightning-induced surge current flow. The object is to reduce the possibility of unwanted and harmful current flow and electrical arcs among devices and components.

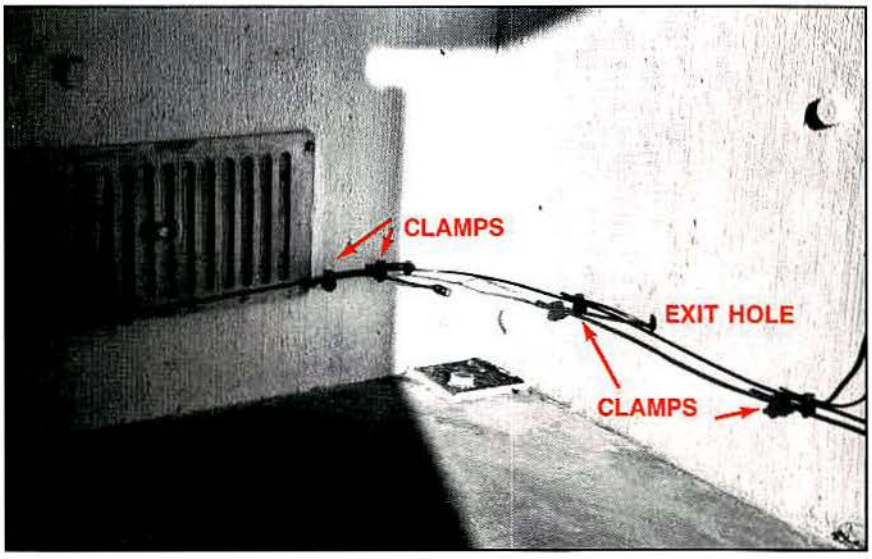
Additional protection is gained through the use of surge-suppression devices that prevent unwanted current flow on ac and telephone lines beyond their entry into equipment shelters.

The majority of the equipment shelters are unattended most of the time. But aside from protecting workers who may be at a given site when lightning strikes, the protective measures are intended to safeguard a radio-operated supervisory control and data acquisition (SCADA) system.

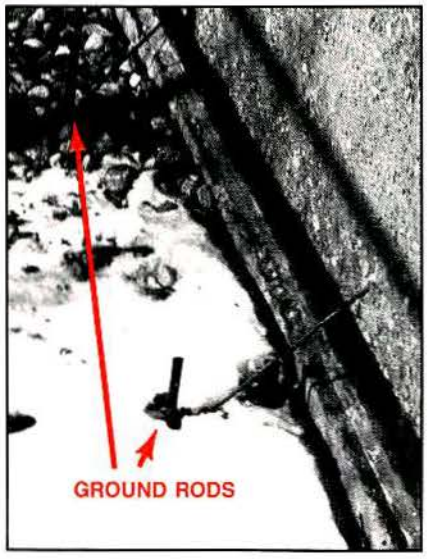
The SCADA system maintains the integrity of a system of 24,000 miles of natural gas mains and a 700-mile transmission network that links purchase points and storage fields to the distribution system. The system is the nation's fourth largest, serving nearly 1.6 million customers in a northern Illinois district that excludes Chicago and some of its north-shore suburbs.

The SCADA system includes 14 cell groups controlled by a master computer at the NI-Gas General Office's Gas

Domanus is control systems supervisor for Northern Illinois Gas, Aurora, IL.



The ground ring inside the building connects through holes in the wall to the exterior grounding bed. Note: Clamps may be acceptable for interior connections, but exothermic welding is recommended for exterior connections.



Ground wires exit the building through 45°-angle holes to connect with ground rods.

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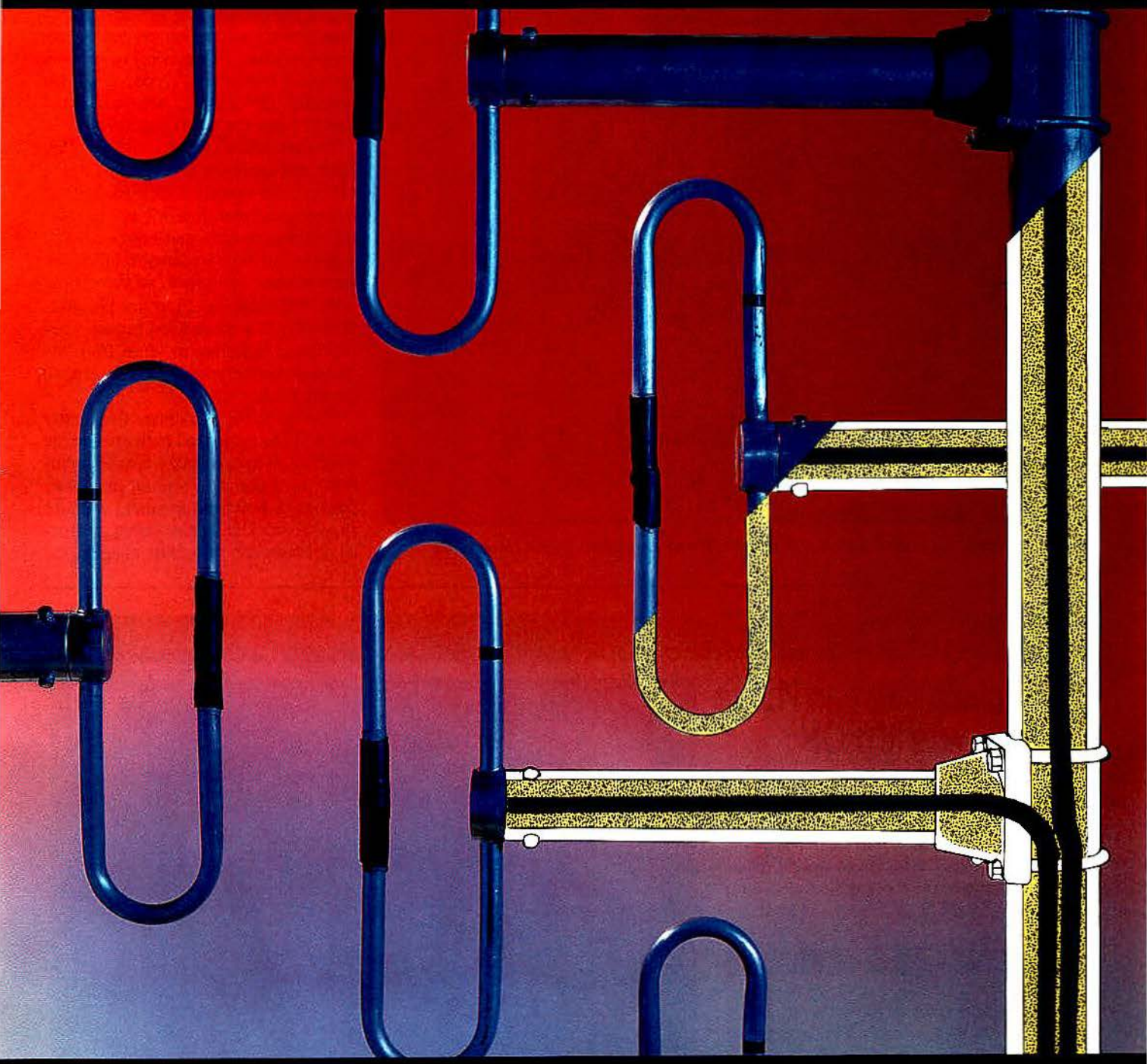
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DB636/8	406-512	6 or 8	600	DSD, up to 40 MHz bandwidth
DB580/3	806-960	0 or 3	400	Mirage 1.5" (38.1 mm) radome
DB586/9 (photo)	806-960	6 or 9	400	Mirage, 3° or 6° electrical downtilt optional
DB806/9	806-960	6 or 9	500	DSD, optional 3° or 6° electrical downtilt
DB806D/TL (photo)	806-960	6 each	500	Dual or triple DB806 antennas
DB803Q	806-960	3 each	500	Quad — air-to-ground radio telephone
DB812F (photo)	806-960	12	500	DSD, 0.5° electrical downtilt standard
DB812HF	806-960	12	1000	HP pressurized model inputs 1200 watts
DB859/60	806-960	9 or 10	550	Optional 3°, 6°, 10° electrical downtilt

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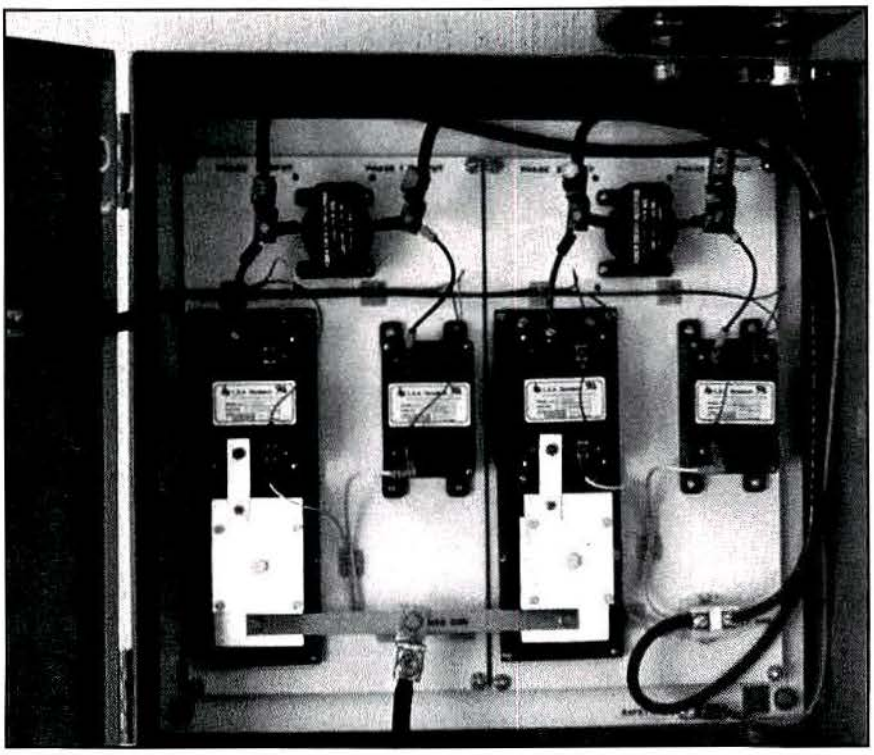
Sinclair's 210 and 310 rugged antennas have established a record of performance under adverse conditions with users who demand performance and dependability.

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The open box shows the type of surge eliminator installed at cell tower sites.

possibility of a resistance increase caused by corrosion or cathodic action among the strands. The wire and ground rods provide a common ground system for connecting all electrical equipment grounds. It provides a connection for bonding the shelter, any additional shelters and the tower together.

The arrangement maintains the equipment and the tower at the same electrical potential to reduce the possibility of unwanted current flow or electrical arcing among devices and components.

Lightning has a tendency to follow the path of least resistance, so the copper wire was kept as short as possible. Sharp bends were avoided because they can cause lightning to jump from the desired conductor and pass to ground destructively.

Coaxial cable that enters the shelter has a lightning ground path outside the building. Where it makes a wide-radius bend to enter the shelter, it passes through a bulkhead-mounted impulse suppressor. The suppressor is grounded through the bulkhead plate to the

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common ground bed.

Power surges caused by lightning strikes to nearby power lines or by electric utility switching and load changing are blocked by a surge eliminator connected between the service entry point and the electrical distribution panel.

Figure 2 on page 40 shows a typical cell tower site installation.

Retrofitting protection

At two locations, Rockford and Kankakee, the cell microcomputer was installed in an existing division office facility with a history of lightning problems. These problems were compounded by the site towers being adjacent to the buildings, which are in wide-open, rural areas near a high-voltage transmission line.

The first attempts to install lightning

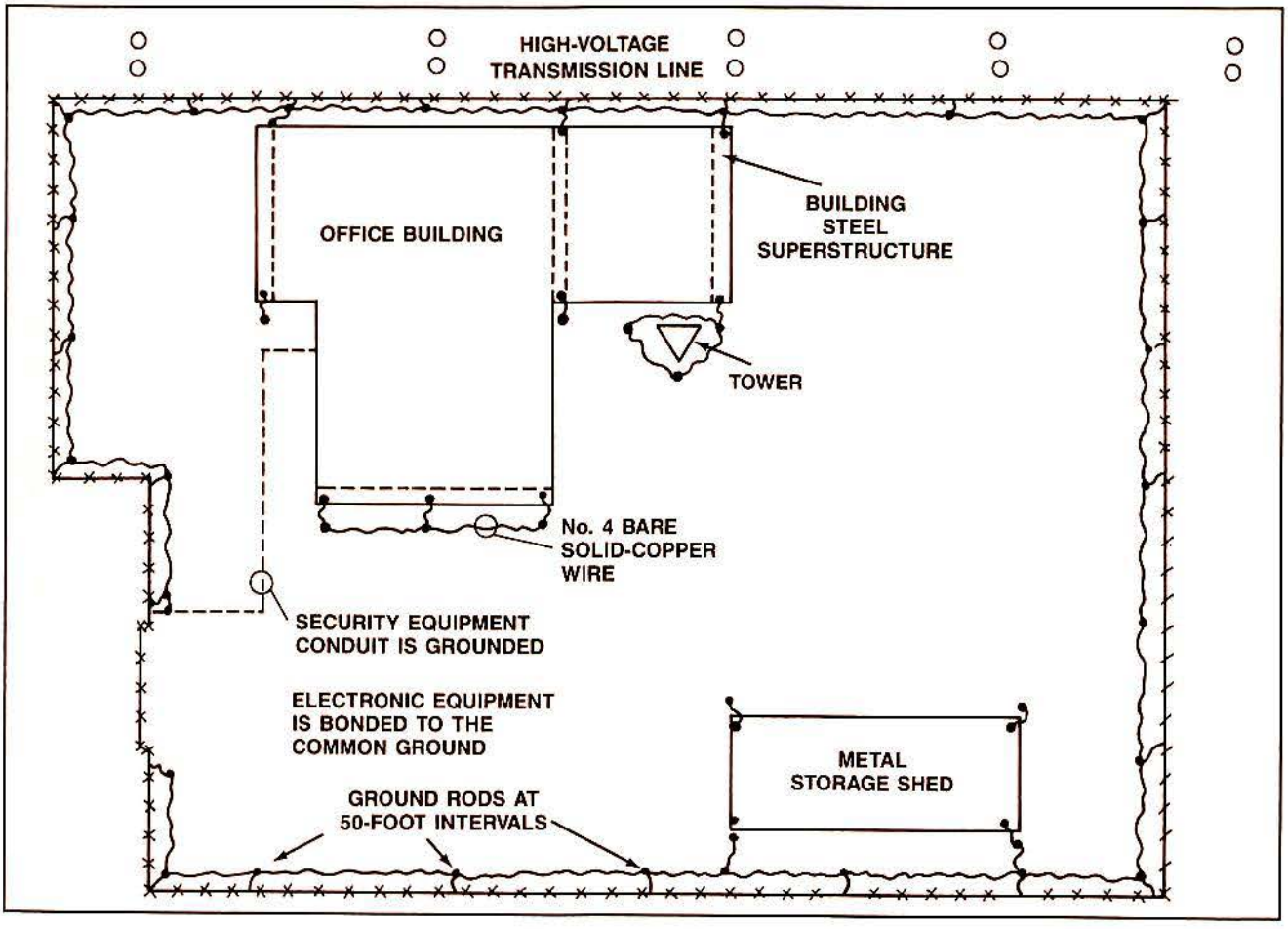


Figure 3. The building layout at the Kankakee cell tower site includes extensive grounding. The cyclone fence is bonded together with ground rods driven at 50-foot intervals around the perimeter.

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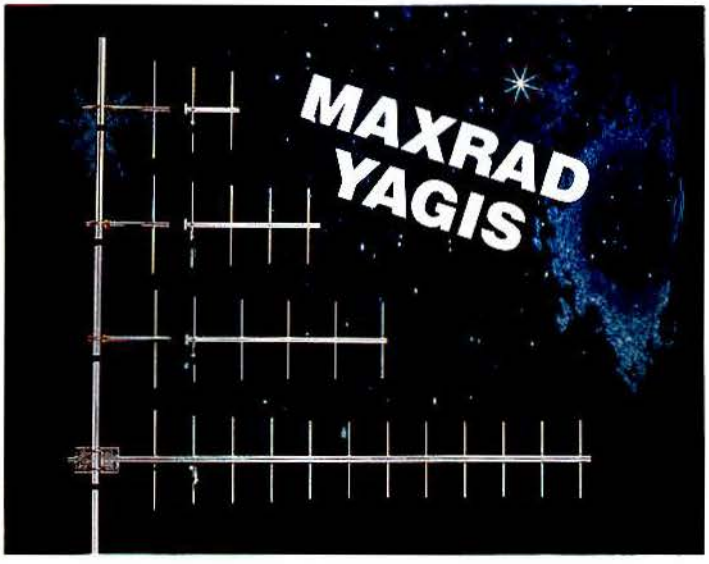
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protection at Kankakee proved futile. On two occasions, lightning-induced surge currents caused the loss of the cell microcomputer, radio, telephone, computer terminals and security monitoring equipment.

Similar experience at Rockford led to a successful remedy that later was employed at Kankakee. Figure 3 on page 46 shows the building layout at Kankakee and the extensive grounding.

The cyclone fence was bonded together with ground rods driven at 50-foot intervals around the perimeter.

New ground rods were driven at positions around the main building. They were attached to the building's metal superstructure and to the tower ground bed.

The metal storage shed was grounded and connected to the fence grounding and the building grounding to make one large common grounding bed.

A surge eliminator was installed on the cell tower microcomputer and radio system. Following a test of receptacles for proper grounding, plug-in-type surge protectors were installed on the remaining electronic equipment.

Shielded cables and conduit entering the building for the security system were connected to the common ground.

For added protection, a multipointed brush-type metal air terminal was installed near the top of the tower. The object is to reduce the buildup of static electricity by dissipating the static charge before it reaches a critical flashpoint.

...Mother Nature has been kind.

After two years of operation with the retrofitted lightning protection, no lightning-induced problems have been experienced at these sites. Either the job was done properly, or Mother Nature has been kind.

The installation of a 300-foot tower at Crystal Lake created a lightning problem. The tower was installed 50 feet north of a 50-foot × 150-foot metal storage building. The electrical service pole first delivers electricity to the metal building. From there, service wires stretch across the parking lot to the headquarters office.

Employees at Crystal Lake complained about losing some of their electronic equipment every time a "dark cloud" rolled across the sky.

The problem was corrected by properly grounding the metal storage building, the electrical service, the tower and the tower guy wires as was done at the other locations.

Seventy remote terminal unit site buildings were protected to a lesser degree but with the same results as were obtained at the cell tower sites.

The 20-foot towers were grounded with a single ground rod connected by No. 4 bare copper wire to the incoming electric service ground.

Low-capacity surge eliminators protect the RTU and its battery charger. At some stations with a history of lightning strikes, transducers are protected by individual surge eliminators.

The coaxial cable is fitted with a surge suppressor connected to the common ground that serves the electronic equipment.

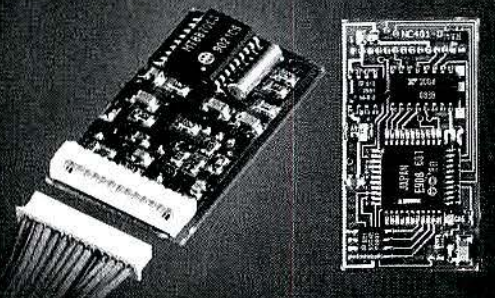
Experience with this lightning protection method has proven many times over to save time and expense.

In five years' operation, only one cell tower site has been lost due to a severe lightning strike that damaged city telephone and electric utility equipment, too. Damage at the site involved the radio and microcomputer. The surge eliminator fuse blew, preventing damage to other electronic equipment.

After repairs were made, a multipointed brush-type metal air terminal was installed on the tower for additional protection.

In separate incidents, several RTU station site fuses blew during high surge current flow. The protection safeguarded the station equipment and allowed technicians to restore the station in minimum time.

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Multiple address systems: Putting new channels to use

Radiopaging system operators and other prospective users of the 'new' MAS frequency band face multiple challenges. Among them are license lotteries, competition from speculators and potential interference.

By Klaus Bender

New frequency allocations are rare and exciting. The 900MHz multiple address system (MAS) frequency allocation in FCC Gen. Docket 82-243 is no exception. The following information explains the allocation, how MAS frequencies are used and some potential pitfalls for new users.

MAS—What is it?

In 1981, the FCC reassigned the 950MHz band for use by point-to-multipoint systems, otherwise known as "multiple address systems"—MAS. The band previously was allocated for omnidirectional systems, such as traffic signal controls. MAS service was intended for use by Power Radio Service eligibles to monitor electrical substations, gas mains and water pumping stations.

MAS frequencies were designated for two-way operation. A "master station," normally placed in the center of the operational area, would transmit information to "remote units." The master station used 25kHz-wide channels in the 952MHz band. With a minimum of four remote units, omnidirectional operation of the master station was allowed.

Potential users loved the idea. Many other uses were discovered for the frequencies. For example, alarm companies wanted to use the frequencies to monitor burglar and fire alarms via two-way radio communications.

In 1982, the FCC amended its allocation. It made available 14 frequency pairs to "general" applicants and 20 frequency pairs exclusively to Power Radio Service eligibles.

Several lobbying groups asked for one-way, omnidirectional service, so the FCC included eight channels in the 956MHz band for one-way use. Common carriers wanted to use MAS spectrum, too, so the commission allocated six frequency pairs to common carriers, with remote units at 928MHz and master stations at 959MHz.

Applications, mostly from alarm companies, were filed quickly. The general access pool channels soon were depleted in the major markets, even as other uses for the spectrum still were being developed. Demand for these frequencies increased to such a level that congestion forced the FCC to review its allocation policy.

First revision

The FCC first attempted to relieve congestion by dividing the 25kHz-wide channels into two 12.5kHz-wide channels. In addition, the agency reduced the mileage separation between master stations to 90 miles. These actions were taken in Gen. Docket 87-5.

The 12.5kHz channels were made available in addition to the existing 25kHz channels. Licensees of systems on 25kHz channels were "grandfathered" indefinitely. Because splitting their channels would double their capacity, the "grandfathered" licensees had an incentive to buy new 12.5kHz equipment when it became available.

As licenses for 25kHz-wide channels were converted, canceled or allowed to expire, the FCC enacted stringent guidelines to limit future requests for 25kHz-wide channels. Data rates of 9,600 baud or higher, plus a detailed technical showing, were required to support an application for a 25kHz channel.

Despite the mileage separation change and the channel-splitting, congestion in the major markets continued. It became apparent that a new allocation was needed.

Second revision

In November 1984, the FCC adopted a *Report and Order* in Gen. Docket 82-243 to allocate the 932MHz-to-935MHz and 941MHz-to-944MHz bands for government and non-government fixed use on a co-primary basis. Private, common carrier and broadcast auxiliary, as well as government users, would be eligible to share these bands. What's more, except for a few "grandfathered" broadcast auxiliary stations at 942MHz and 944MHz, these bands were relatively virgin spectrum.

The allocation originally was intended to serve point-to-point, fixed microwave radio users. But several organizations lobbied the commission to add point-to-multipoint MAS operation to the allocation. The agency agreed, and gave 1MHz of the 6MHz allocation to MAS users.

The FCC divided the 1MHz-wide band into 40 12.5kHz-wide channels and allowed equal access to all applicants. No 25kHz-wide channels were allocated.

The mileage separation between master stations was set at 70 miles, 20 miles less than the previous separation.

On March 15, 1990, the FCC terminated the proceeding in Gen. Docket

Bender is the manager of engineering services at Spectrum Management Systems, a subsidiary of the Special Industrial Radio Service Association, Arlington, VA. He formerly was a microwave engineer with the FCC.

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82-243 with a *Memorandum Opinion and Order* that set forth the band's final technical standards and indicated that a Public Notice would be issued to announce a one-week filing window. Many potential applicants began preparing application forms.

Multiple applications

On June 4, 1990, the FCC issued the long-awaited Public Notice, which specified a July 9-13 filing window. Because the band has no present users, the first round of applications required no frequency coordination.

The announcement read that 5,000 to 10,000 applications were anticipated. To ease the processing of the "massive" filing, the FCC laid plans to award licenses by lottery.

But the FCC did not state a policy regarding the number of applications an individual applicant could file for a particular site. "Spectrum grabbers" noticed the oversight. To increase their chances in the lottery, some applicants prepared as many as 40 applications per site. The FCC charges a $155 filing fee for each application.

The estimate that 5,000 to 10,000 applications would be filed soon rose to 20,000 and higher. Given the processing burden the applications would represent, estimates as to how long it would take to issue the first point-to-multipoint licenses ranged from 12 months to 18 months—and these estimates were considered conservative.

Many of those eligible for licenses believed that to allow potential licensees to file multiple applications for a given site would abuse the lottery process. The Utilities Telecommunications Council (UTC) filed a "Petition to Stay the Filing Window." The petition read that, no matter how applicants chose to file their applications, someone would be treated unfairly if individual potential licensees were allowed to file multiple applications for the same site.

The FCC agreed with UTC. On July 2, 1990, one week before the filing window, the FCC released an order to stay the filing window.

On Oct. 12, 1990, the FCC requested comments from the public on the subject of potential licensees' filing multiple applications for a given antenna site. The filing window will not be opened until all the related issues are resolved.

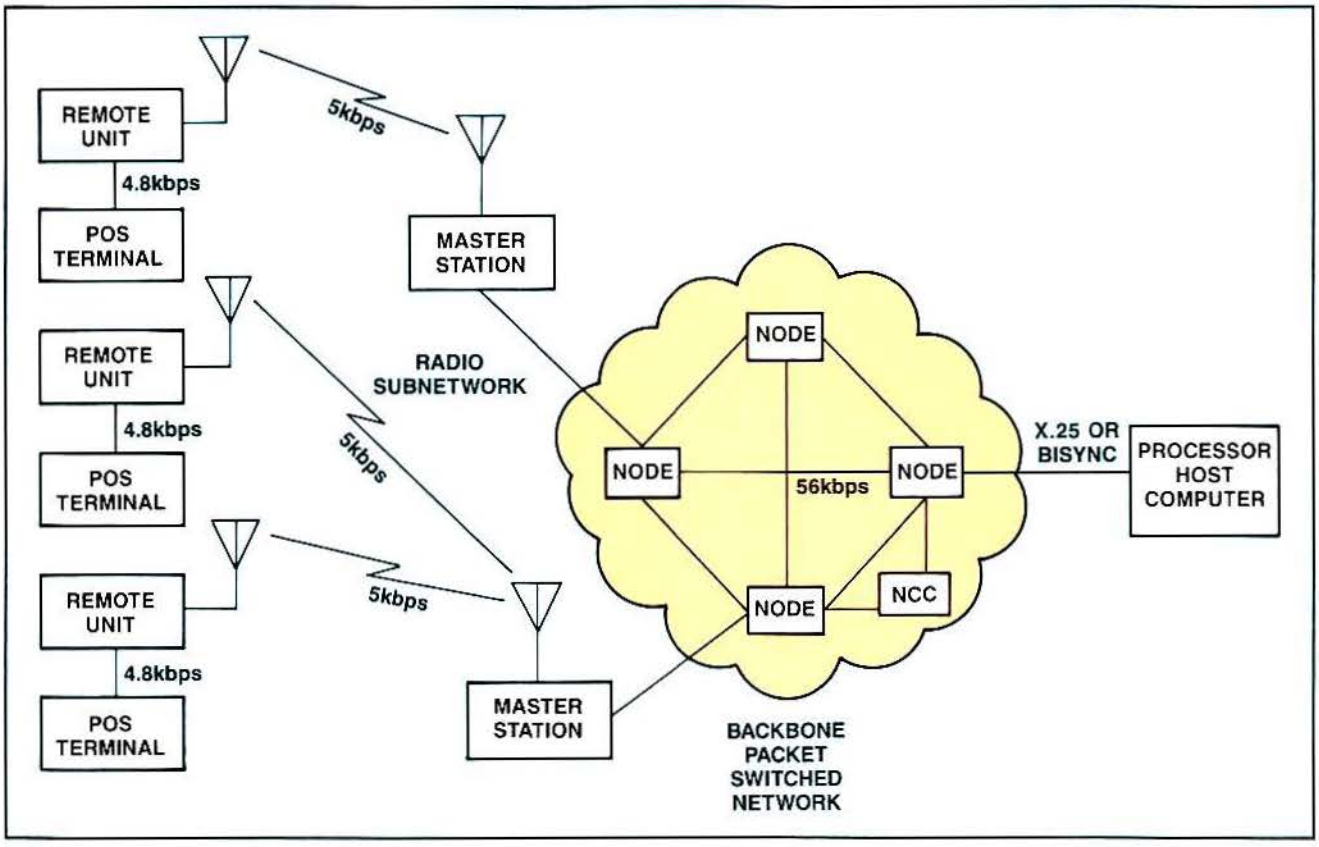
Although some potential applicants are unhappy at the possibility of having to wait until mid-1991 to apply for licenses, the delay offers an opportunity to examine the new allocation and to identify critical issues.

MAS and its uses

An MAS can be used for any situation requiring data transfer to and from a relatively large number of sites. Both the master station and the remote units must be in *fixed* locations.

Oil companies use the frequencies to monitor well sites. Natural gas companies monitor pipeline gas flow. Banks verify credit cards and automatic teller machine (ATM) operation. Local governments use multiple address systems to connect computers that do not require high data rates.

The one-way 956MHz and common carrier allocations are used to control paging systems. One of the few non-



This block diagram shows the elements of a multiple address system of the type operated by Digital Radio Networks, Vienna, VA, for credit card (POS) verification services.

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digital uses for these systems is the distribution of background music on 956MHz one-way channels.

Utilities developed new uses. The 956MHz channels were made available for mobile meter-reading systems—the *only* mobile use allowed on these frequencies. In such systems, a radio-equipped truck reads power meters as it passes by. The power meters transmit the readings on low-power, unlicensed transmitters on Part 15 radio frequencies. The transmitter in the truck uses a 956MHz MAS channel to send data to a central station.

Another measurement device, the Power Donut meter, clamps onto a power line to measure current flow and send the information via MAS radio frequencies to a central station.

Networks that carry financial information have been developed around the use of MAS frequencies. Complex, multistation systems have been licensed at locations throughout the country.

Entrepreneurs have been speculating on radio spectrum for years. Their efforts have included the broadcast services and the private radio services, such as the specialized mobile radio (SMR) frequencies at 800MHz and 900MHz. It is only to be expected that some speculation would occur with the new MAS allocation.

Those who have no actual use for an MAS now have more time to consider the speculative value of an MAS license.

An MAS may be just the type of radio system a company needs to fulfill its internal communications requirements. But the potential income value of the license does not approach that of an 800MHz SMR license. Those who have no actual use for an MAS now have more time to consider the speculative value of an MAS license. Research should show that the price an actual user would be willing to pay for access to MAS frequencies in the new band will be relatively low, even in major markets.

The reason is MAS income is relatively low, compared to other radio systems. Multiple address systems with 500 to 1,000 "paying customers" are rare, no matter what data the system carries. Most bona fide MAS users would seek other means of communications, rather than spend $50,000 to "buy" an MAS from an entrepreneur.

High demand areas

The highest demand for these frequencies in the top U.S. markets will come from common and private radiopaging carriers that want them for remote control purposes.

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ty compared to leased telephone lines.

Packet data networks may appear on the MAS frequencies. In areas where the original frequencies are exhausted, some traditional MAS users may appear on the new frequencies. Power companies wanting to expand existing multiple address systems will look to the new frequency band.

An emerging area of high demand is in the Gulf of Mexico, where offshore oil production activites use MAS extensively. Oil field operators in Texas, New Mexico, Oklahoma and California are expected to file a large number of applications, too.

License issues

The MAS proceeding is the FCC's first attempt to allow non-government users to apply for the same spectrum as government users. Non-government users will file applications with the Common Carrier Bureau, the Private Radio Bureau or the Mass Media Bureau. Government users will file applications with the National Telecommunications and Information Administration. This situation raises several licensing issues that the FCC has yet to resolve publicly.

Combining all these applications and deciding which applicant gets which channel will be a difficult task. All applications must be put on public notice, both for the initial filing window and later, when applications can be filed on a first-come, first-served basis.

Packet data networks may appear on the MAS frequencies.

Combining the applications will be difficult if, as expected, agencies such as the Federal Bureau of Investigation and the Drug Enforcement Agency are reluctant to provide the locations of their proposed systems, let alone those systems' technical characteristics.

The issue raises concerns with frequency coordinators, who are required to maintain accurate records for use in recommending frequencies for their clients. One fear is that applications filed by non-government users will be dismissed as defective because of a previously filed government system license application, with no additional information being made available about the government system for security reasons.

Another issue involves the construction requirements placed on these systems. Both the Private Radio Bureau and the Common Carrier Bureau require that an MAS be constructed within one year of the license grant. Will government systems be treated the same? How will coordinators be notified of government system license cancellations?

When the FCC divided the new frequency band into channels, it allocated

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40 *pairs* of frequencies. Frequency pairing implies two-way use only. The two-way restriction was not favored by applicants who need one-way communications.

To meet the one-way communications need, the rules for the new MAS band allow one-way communication. Applicants may split a frequency pair and use only one frequency.

The FCC took steps to reduce the number of "orphaned" channels that have only one of the paired frequencies in use. The agency ruled that, if remote units are within 48km of their master station, the 932MHz frequency must be used as the master station frequency. The 932MHz frequencies have a lower maximum power limit.

If the proposed system has remote units more than 48km from their master station, the 941MHz frequency may be used for the master station.

The FCC apparently expects this procedure to reduce the number of orphaned channels, but it will make future frequency coordination difficult.

When the filing window eventually opens, applications still are expected to number from 7,000 to 15,000, even if the commission allows only one application from an individual applicant per antenna site. The FCC's use of a lottery to grant licenses means all applications will be lumped together and assigned numbers. The selection process may take 12 to 18 months or longer. Such a delay raises concern among applicants who need MAS spectrum *now*.

The FCC's use of a lottery to grant licenses means all applications will be lumped together and assigned numbers.

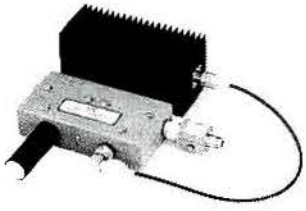
Assuming that the filing window opens in mid-1991, it could be the end of 1992 before the first licenses are issued. Many companies cannot wait that long. They may look elsewhere for relief—in the Power Radio Service MAS frequency pool, more than likely.

Since 1982, the Power Radio Service MAS frequencies have not seen the demand that the general access MAS pool channels have seen. Granted, in markets such as New York and Los Angeles, Power Radio Service MAS frequencies are as scarce as the general access pool channels. But in other markets, Power Radio Service pool channels still are available.

In Docket 87-5, the FCC decided to end the exclusive use of Power Radio Service MAS frequencies for utilities. On Jan. 1, 1992, those channels become available to the general public. That raises the question: Should a potential applicant wait until July 1992 to get a 931MHz/941MHz MAS license? Or should he apply for an MAS license for a frequency in the Power Radio Serv-

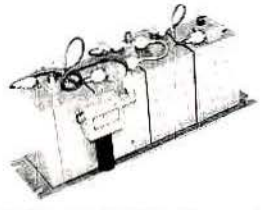
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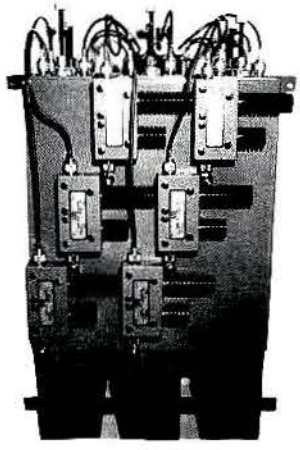
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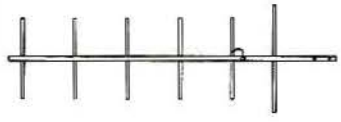
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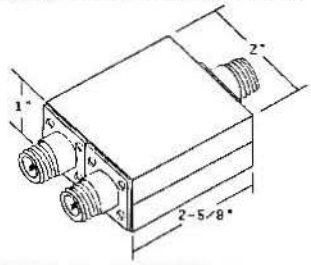
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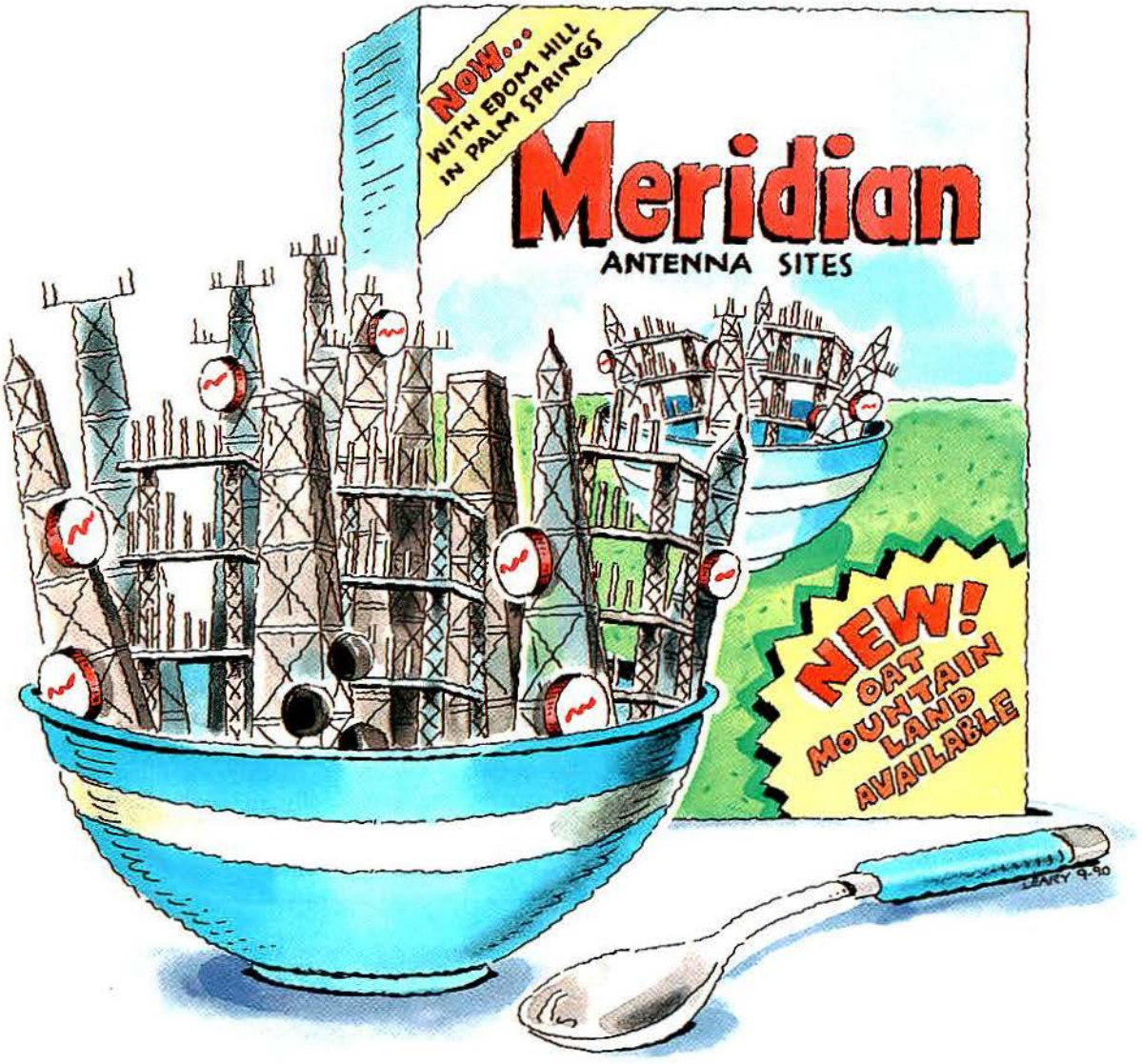
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ice channel pool on Jan. 1, 1992, with the hope of receiving a license as early as May 1992?

The most critical aspect in the design and construction of a 932MHz/941MHz MAS may be the potential for interference. Throughout the country, MAS operations are plagued by an interference problem not anticipated by the commission: receiver front-end overload.

When the FCC allocated remote unit receive frequencies at 928MHz, it gave little consideration to the 931MHz common carrier paging allocation. These paging systems, which are being licensed at a high rate all over the country, operate with power levels as high as 150W to 300W.

When an MAS facility is placed on a commercial antenna site, such as a building rooftop, the site manager usually calculates the possible intermodulation interference to see whether the proposed MAS station is compatible with existing systems. But few site managers check to see if any systems are licensed on frequencies close to the MAS receive frequency of 928MHz. When the paging system begins transmitting on 931MHz, the power levels are so high that the MAS receiver generally is desensitized so greatly that it becomes useless.

Some site managers even put all 900MHz systems in the same section of the antenna site, so the paging antenna could be within 15 to 20 feet of the MAS antenna. If this situation already causes problems with the 928MHz MAS receive frequency, imagine how much worse it will be with an even closer MAS receive frequency of 932MHz. The results could be devastating for new licensees who do not adequately research a proposed antenna site.

Remember the discussion of "orphaned" channels, whose frequency pairs are split to allow one-way communications on one frequency of the pair? It is entirely possible that a one-way system could be licensed at the same location as a two-way system, with the 932MHz one-way transmitter on the adjacent channel and an antenna right next to the two-way system's 932MHz receive antenna.

The prospect of conflicts with paging systems and co-located two-way and one-way multiple address systems makes antenna site selection critical. Anyone who intends to build a system in the new MAS band should expend the effort required to find a suitable construction site *before* applying.

Much to think about

Potential MAS users who intend to file for frequencies in the new MAS band have much to think about in designing their systems. They must select a well-managed antenna site and develop a good relationship with the site manager. They must weigh the potential use of the frequencies, the time required for license assignment and the other licensing issues involved.

Perhaps the filing window stay actually is a blessing for potential applicants.

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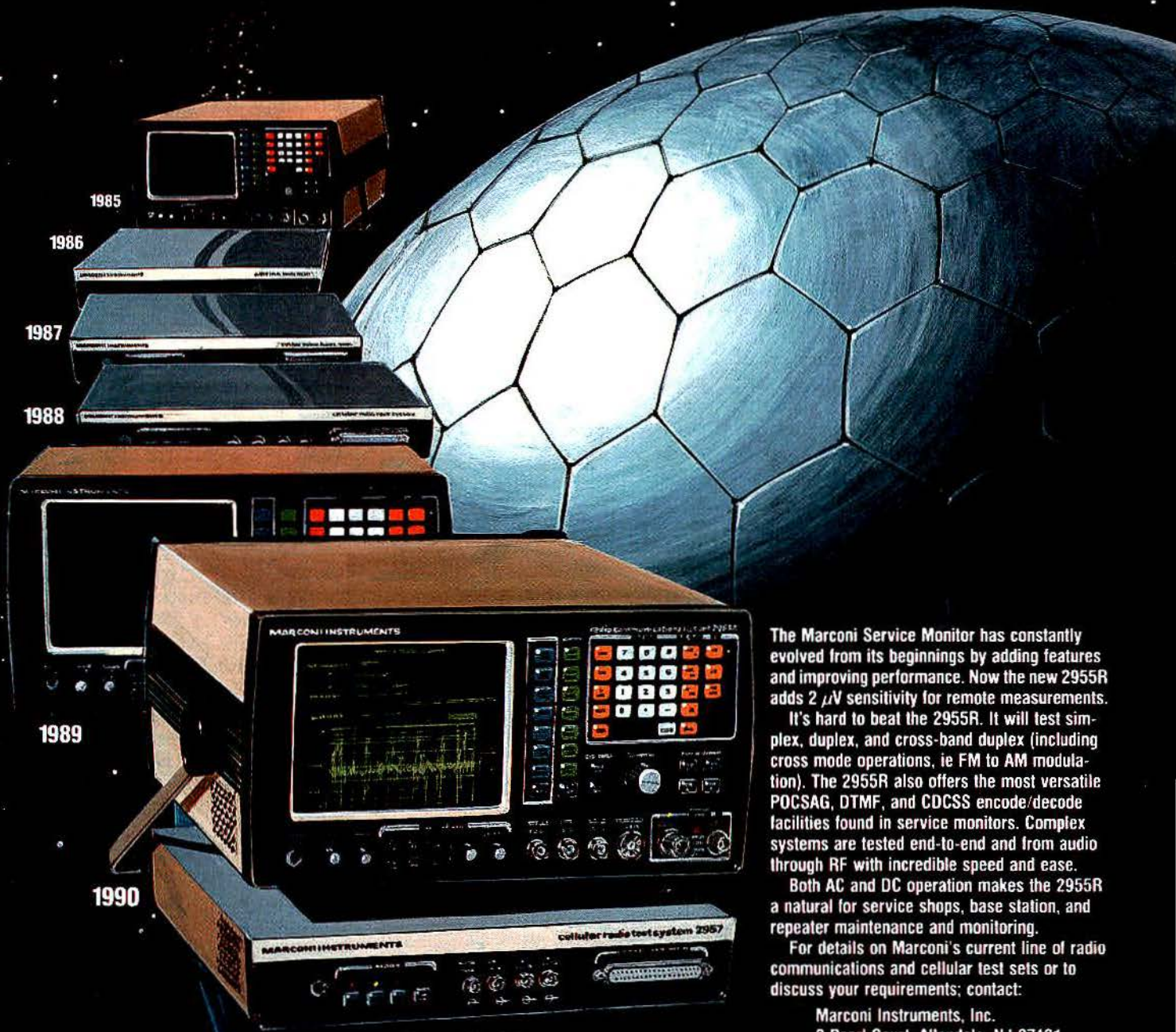
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Digitally coded squelch: Filtering and decoding

Part 2—Digitally coded squelch systems use active audio filters extensively. Encode and decode filters greatly affect performance. The deceptively simple decoding algorithm invites problems for the unwary designer.

By Mark Nadir

Fundamental characteristics of the (23,12) binary code used for digitally coded squelch (DCS) are explained in part one of this series, which appears in the November 1990 issue. Although the codeword is purely binary, the method of data transport is analog. Analog transport methods and the subsequent binary processes that decode DCS signals are explained in part 2 below.

Nadir is president of Globestar Technology, Ft. Lauderdale, FL. (Telephone 305-763-1569.) The company specializes in digital radio system design and implementation for clients worldwide.

Transmission and reception of DCS signals are facilitated by the use of a continuous, subaudible analog channel on the radio carrier. As with continuous-tone controlled squelch system (CTCSS) signaling, DCS signaling is superimposed, concurrently, with voice signals on the FM radio carrier.

Voice and DCS signals each are apportioned separate parts of the audio spectrum. Consequently, DCS systems include audio filters to prevent contention between subaudible data and voice-band message traffic. A low-pass encode filter keeps low-speed DCS signals within the subaudible band. A similar decode filter recovers the DCS signal from the composite received signal.

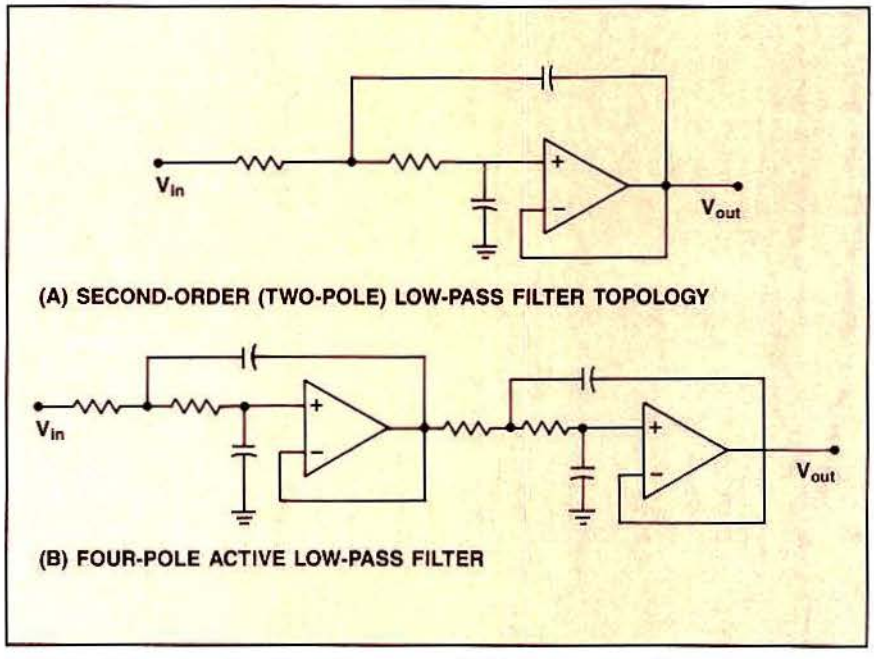


Figure 1. These circuit configurations are suitable for low-pass filters. Cascading two second-order filters (A) in series makes a four-pole filter (B).

In comparison to the single tone used by CTCSS systems, the DCS signal spectrum occupies considerably more bandwidth. A low-pass filter that does not seriously distort a single-frequency tone signal may seriously degrade a wideband signal containing multiple frequency components. The distortion risk is especially high if the filter delays the wideband signal's frequency components differently. Therefore, although tone and digital squelch systems use low-pass filters to perform similar functions, the filters' design requirements differ.

Digital squelch filters

To reduce the DCS signal's audible feedthrough, the binary signal is fed through a low-pass filter to remove its higher harmonics. This "encode filter" converts the digital signal into a filtered analog signal, which is applied to the radio modulator. Despite the filtering, most listeners can hear the familiar DCS "grunt" in the received audio because the ear has a large dynamic range.

The encode filter's function may seem relatively straightforward. Yet for a variety of reasons it represents the first in a series of essential compromises.

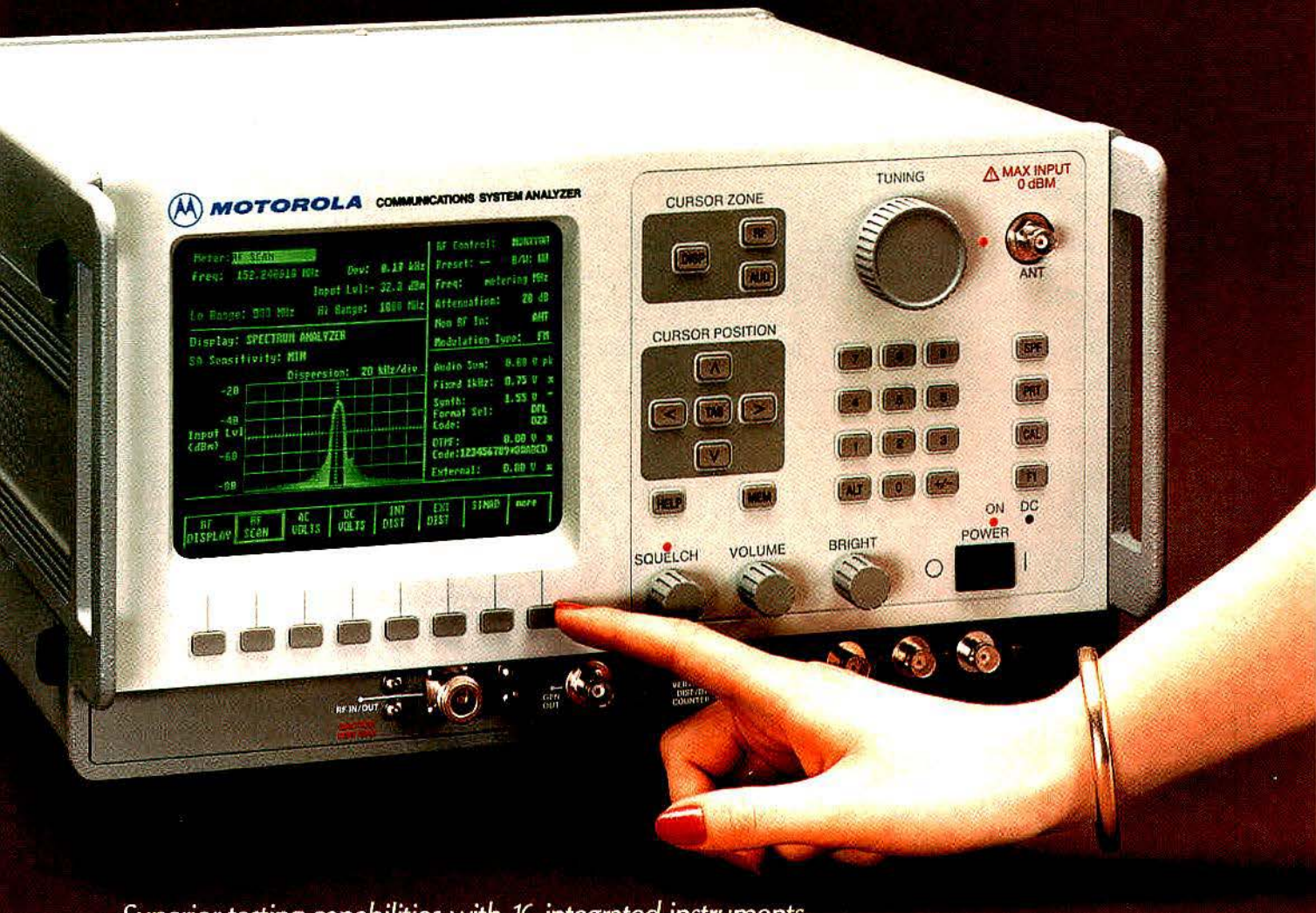
First, when it converts the digital signal to an analog signal, it distorts the signal as it performs the necessary function of reducing its bandwidth.

Second, the delay introduced by the filter may distort the signal further.

Two components make up the output of a linear filter, such as the encode filter. The first is the *forced response* to the present input. The second component is the *accumulated response*, arising from past output values.

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Stated differently, filter output at any given instant is determined by the present input and a weighted history of *all* past outputs. Thus, the filter has a "memory." If its "memory" is too good and the "historical" contribution is appreciable within an amount of time equivalent to a bit interval, the potential for intersymbol interference (ISI) exists.

Relating this argument to binary bits, the filter output contribution from prior bits may destructively interfere with—distort—the reception of the present output symbol.

Suitable complex low-pass filters to fit DCS applications can be built with cascaded first-order (one-pole) and second-order (two-pole) filter sections. Handbooks have been published that explain the procedures used to synthesize active filters.

Figure 1 is a circuit configuration suitable for a second-order low-pass filter. A four-pole filter can be made by cascading two such circuits in series.

The four-pole filter offers an ideal method for comparing two different filters' performance because some filter work better than others for processing binary data.

To illustrate some functional variations between different filters, an A filter for analog signals and a B filter for binary signals will be compared.

...filters to fit DCS applications can be built with cascaded first-order and second-order filter sections.

Both are 4-pole low-pass filters with a −3dB cut-off frequency of 150Hz. The cut-off frequency is selected to avoid seriously attenuating the 134Hz tone that serves as the "turn off" code.

Figures 2 and 3 on page 64 show filter outputs that result from applying the random binary sequence "1001110100001110100011101" to their inputs. The "ringing" at the A filter output shows the potential for ISI.

According to the DCS polarity convention, a logic 1 is transmitted by a positive RF carrier frequency shift and a binary 0 corresponds to a negative shift. Thus, the *symbols* that convey the binary (1,0) information across the radio channel are $+1\triangle F$ and $-1\triangle F$. The $\triangle F$ ("delta F") represents an arbitrary shift in the radio carrier's instantaneous FM deviation, typically 500Hz.

For simplicity, the transmitted signals simply are referred to as ± 1. Because the symbol is either a −1 or a +1, the binary signal can be recovered by detecting the signal's "zero crossings."

If a limiter were used to convert the analog signal back into a binary sequence (A/D), then the recovered signal's distortion could be measured by observing how accurate the "zero crossings" remained. To visualize the con-

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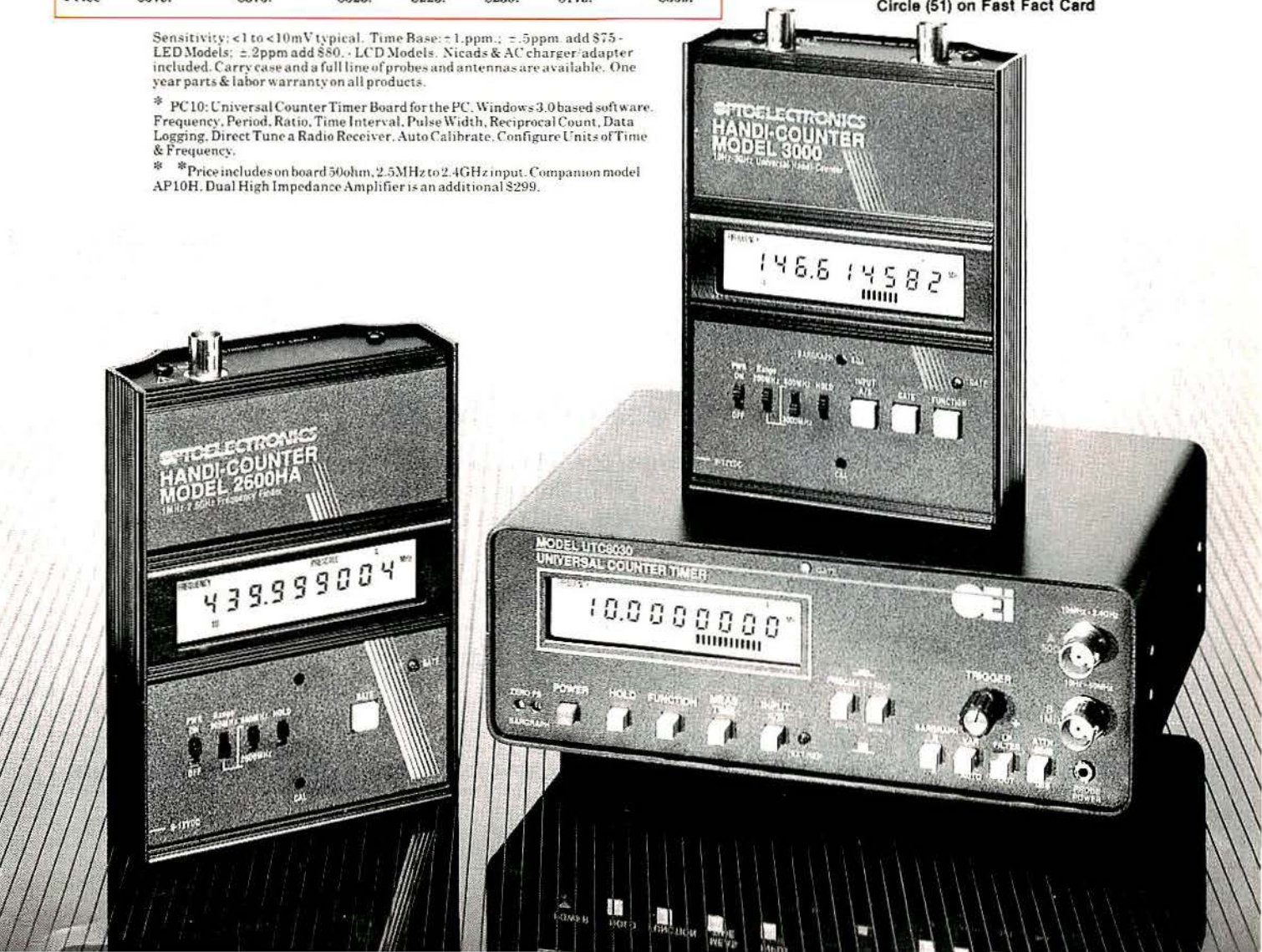
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version, imagine the waveforms in Figures 2 and 3 as though they were "folded" about a time axis with precisely an integer number of bit intervals. With a two-bit time window, a revealing "eye" pattern can be drawn. Eye patterns are shown in Figure 4 on page 65 for the B filter and Figure 5 on page 65 for the A filter.

The patterns indicate that the B filter, designed specifically for digital data, appears to be the better of the two filters. But that conclusion may be premature because the A filter's zero crossings are perturbed only slightly. Nevertheless, the filters in this example represent ideal low-pass filters coupled down to dc. In contrast, many real systems are capacitively coupled, for valid reasons.

Moreover, only one filter is considered in the example, yet functional digital squelch systems use two low-pass filters, one for encoding and the other

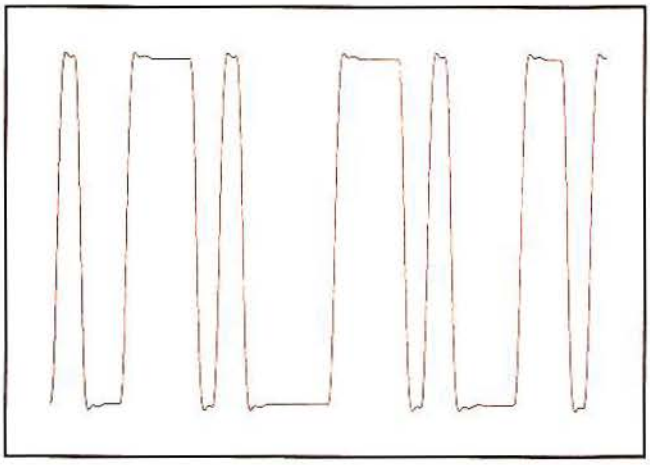


Figure 2. The output from a 'binary' filter designed to process digital data.

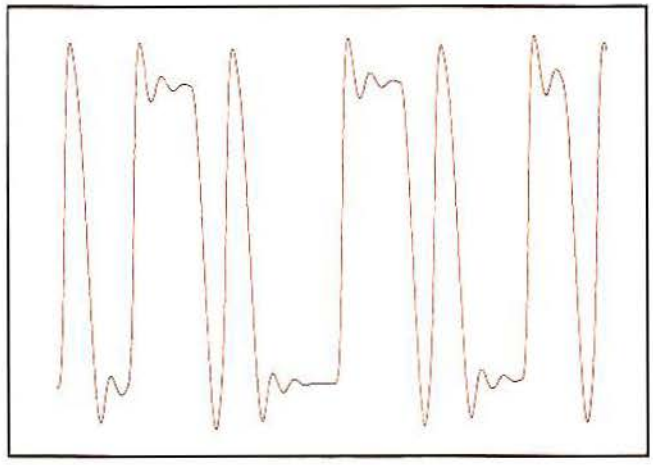


Figure 3. The output from a typical 'analog' filter used to process single tones.

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for decoding. When accounted for, these factors would produce eye patterns that show more degradation than the patterns reproduced here.

Despite the appearance of the B filter as the better selection, it is, in fact, not usable either as an encode or a decode filter. Figure 6 on page 68 displays both filters' attenuation characteristics and reveals why the B filter is not the best selection.

The B filter (solid line) has about 15dB less attenuation for frequencies above 300Hz than the A filter (dotted line). In practice, the A filter probably would be the better choice for DCS design because it offers better rejection of voiceband signals. Plainly, the earlier reference to the encode filter as "the first in a series of essential compromises" begins to take on meaning.

Much of the foregoing information applies to encode and decode filters almost equally. The encode filter process-

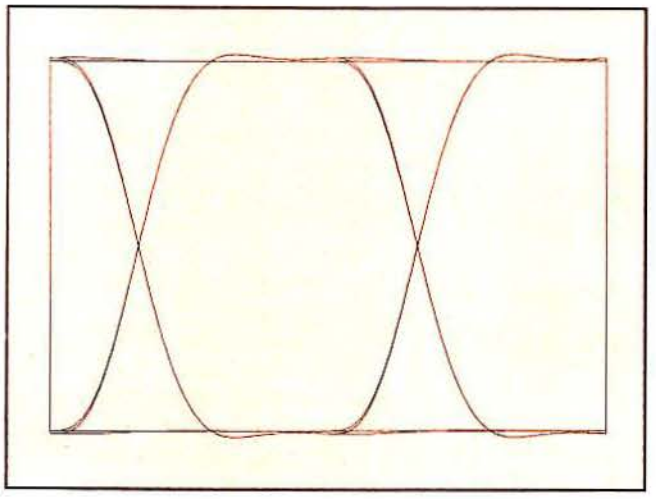


Figure 4. An eye pattern for the 'binary' filter of Figure 2.

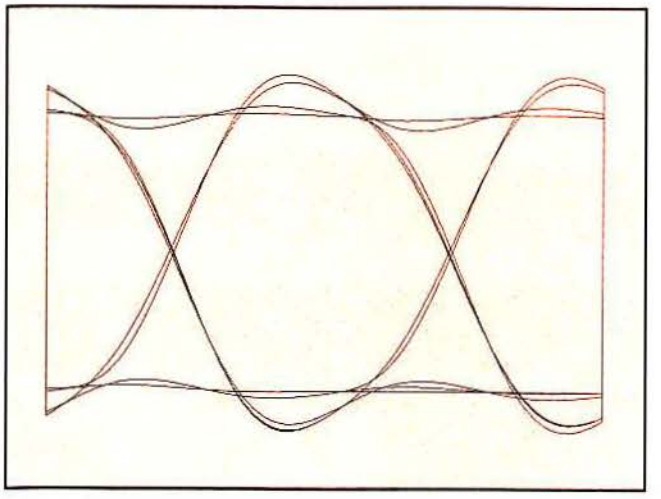


Figure 5. An eye pattern for the 'analog' filter of Figure 3.

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es an input signal with virtually no noise to hinder the filter performance. But the decode filter must work in an entirely different environment, an environment that complicates the filter design. Similar to what was found with the encode filter, the decode filter that theoretically is best suited for digital decoding is not the one that works best in practical systems.

If DCS systems did not have to function in the presence of noise, filter selection would not be so important. With strong radio signals, only an extremely poor filter can degrade the digital signal enough to prevent successful decoding.

But users expect radios to work under reasonably adverse conditions in the presence of noise. Noise causes jitter in the decode filter eye patterns and causes bit errors to occur in the received DCS data stream.

To complicate matters further, the decode filter needs sufficient attenuation to prevent voiceband signals from interfering with DCS data reception. Thus, decode filter selection involves a series of carefully studied compromises, similar to those made for the encode filter.

Decoding DCS signals

Several techniques are available for decoding DCS signals. In general, these techniques are not closely related. Each algorithm has its advantages, limitations and degree of computational complexity. "Fine tuning" is required to reduce adverse "side effects" peculiar to the technique selected.

Several DCS product vendors use the decoding method described here for commercial applications. Fortunately, the method is easy to understand and, with suitable modification, it works in practice. But do not be misled by the algorithm's deceptively simple appearance.

...improvements often are protected as trade secrets.

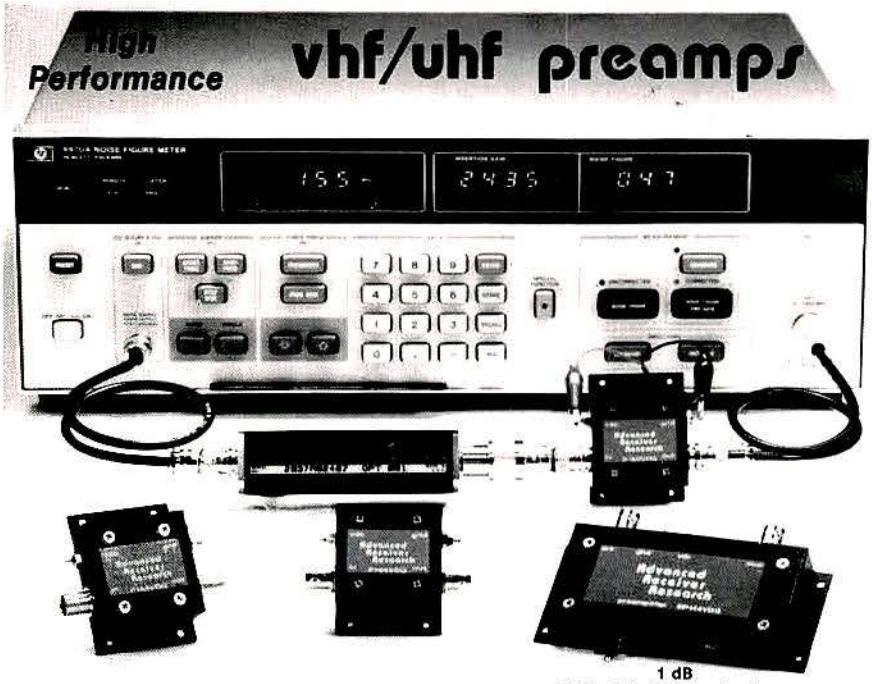
In the form described here, the algorithm is only marginally adequate for decoding. As implemented in commercial products, the algorithm is highly optimized compared to the version shown here. A DCS equipment vendor's improvements to the basic algorithm may substantially improve a decoder's performance. Those improvements often are protected as trade secrets.

Some of the important decoder requirements include:

(1) Decoder attack time—the time it takes the DCS decoder to detect a valid codeword—is critical. Voice communication is not possible until the decoder detects the presence of the proper DCS codeword.

(2) The DCS codeword is unsynchronized. The transmitted codeword starts with bit 1 and repeats cyclically

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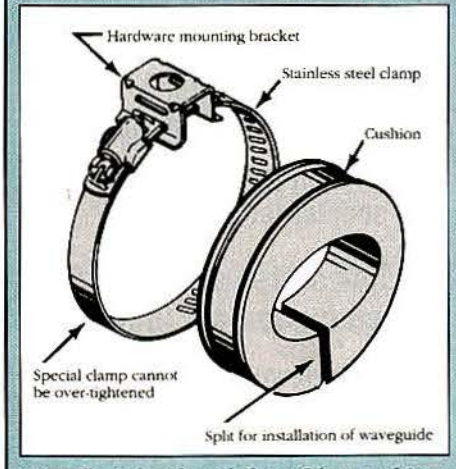
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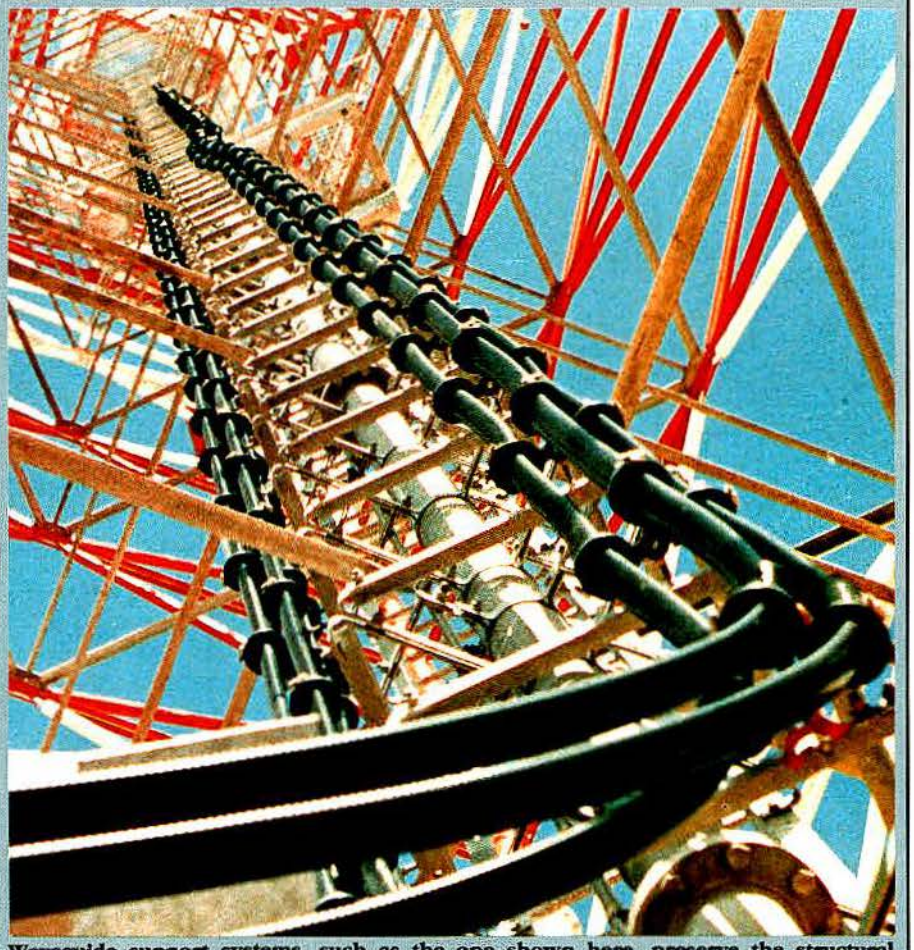
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every 23 bits. The decoder must function without a timing preamble that otherwise might be transmitted to facilitate the recovery of bit boundaries in advance of data reception.

(3) The decoding algorithm must be economical to implement. For example, it must not consume excessive time from a microprocessor assigned to make the computations.

(4) The decoding technique must distinguish one codeword from another

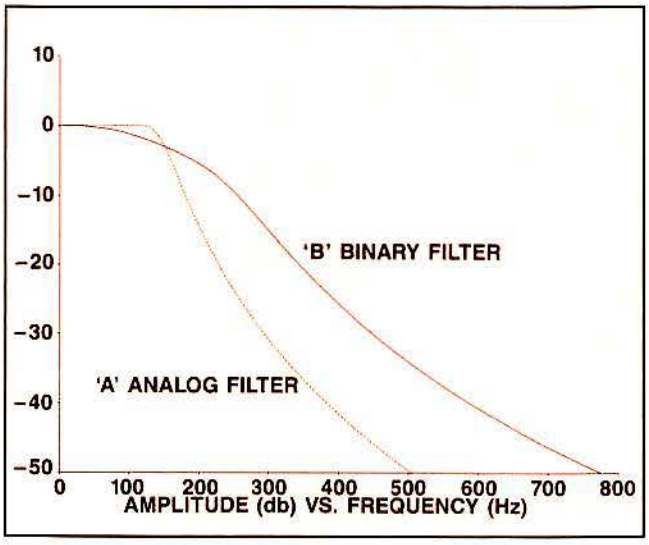


Figure 6. Attenuation characteristics of the 'analog' and 'binary' filters.

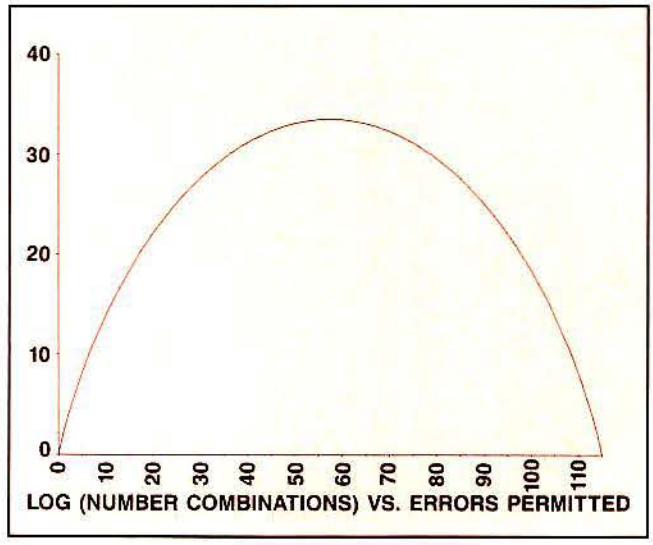


Figure 7. The number of valid samplewords increases in a non-linear fashion as the error threshold increases. The vertical axis is the logarithm of this number. (Note: $Log_{10}0 = 1$ because $10^0 = 1$.)

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adequately and not allow frequent falsing.

(5) The decoding algorithm must function in the presence of noise because the decoder will be required to operate with RF signals at or below 6dB SINAD.

The received signal's zero crossings, after passing through a decoding filter, can be used to determine the received DCS data's bit transitions. Thus, to recover the DCS data, a limiter preceded by a low-pass filter serves as an analog-to-digital (A/D) converter. Once the analog signal is converted back into the binary DCS language of 1s and 0s by the limiter, a decoding algorithm determines whether the selected DCS codeword is present.

The digital squelch decoding technique is called *correlation*. As the name implies, a recovered codeword is compared, bit by bit, against a reference codeword. If there is sufficient agreement between the two, then the input is "correlated" against the reference. Although it is impractical, perfect correlation requires all of the recovered codeword's 23 bits to match the reference codeword bits.

The digital squelch decoding technique is called 'correlation.'

In contrast, correlation can take the form of measuring how many bits *do not* correlate against the reference. This process is called *anticorrelation*.

Correlation measures the compliance a candidate codeword has against a known sequence, which means how well the patterns match. Requiring perfect correlation (a perfect match) is no different than requiring perfect anticorrelation (a perfect mismatch) because the *patterns* must agree or disagree to the same extent.

In principle, the correlator samples incoming data once per bit and correlates the input against the previous 22 inputs, looking for a specified correlation level. Because the receiving decoder is not synchronized with the encoder, the bit sampling might, by coincidence, occur exactly on the data transition edges, resulting in consistent random errors.

At the instant of sampling, the bit sample may be corrupted by noise. Such corruption causes a bit error that may not have resulted if the sample had been taken at a slightly different time.

Consequently, a sampling rate of once per bit interval may provide a poor-quality representation of the incoming signal, due to sampling anomalies and noise.

To improve the representation of the incoming signal, increase the sampling rate. When the incoming signal is oversampled at five times the baud rate, the correlation length grows from 23 bits to 115 bits. The reference register is 115 bits long, too, but with every five bits identically bitstuffed. Under this condition, bit errors introduced by noise and sam-



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pling anomalies are more uniformly distributed across the five samples per bit. With respect to the information below, the assumption is that sampling is at five times the bit rate.

At each sample input, a new sampleword is available for correlation against an image of the desired DCS codeword. If the correlation value is within a certain threshold, then the incident bit pattern is judged as a close replica of the DCS codeword, and the decoder unsquelches the radio. But where is the threshold to be set?

Part one of this article series explains that the (23,12) Golay code is a perfect cyclic code with a minimum distance of 7. A certain error-correction capability is built into the codeword itself. Under optimum conditions, as many as seven bit errors, or 35 samples, can be tolerated before one codeword is confused with another. This situation implies a lower limit on the error threshold, which is the permissible number of errors allowed in the correlation process. But no upper limit is implied.

The value for the error threshold is determined experimentally. Various radio models may require different values, even with identical DCS hardware.

By allowing more errors, the decoder performs better in noise. Allowing too many errors results in noise falsing.

The sampleword consists of 115 bits or 2^{115} valid permutations, an extremely high number. For a given number of permissible errors, the number of valid samplewords that meets the correlation requirement increases. Permitting no errors (perfect correlation) results in one candidate sampleword. Permitting one error results in 115 candidate samplewords. The effect is not linear, as Figure 7 on page 68 shows. The vertical axis is the logarithm of the value. (Note: $\text{Log}_{10}0 = 1$ because $10^0 = 1$.)

If the error threshold is set to about half the sampleword length, a perfect "noise correlator" results because half the bits are received (randomly) in error. In such a case, the radio channel's random noise causes the decoder to false often. Thus, an upper limit on the error threshold exists.

The value for the error threshold is determined experimentally. Various radio models may require different values, even with identical DCS hardware.

Often, hysteresis is used, meaning the error threshold is increased after a valid DCS codeword is detected. This permits the signal quality to degrade by a measured amount before correlation fails. The hysteresis prevents the digital squelch from "chattering" if the DCS signal is marginal.

Next—More on the theory of digital squelch and correlation, what the DCS vendors don't (and won't) tell you, and how to test digital squelch systems.

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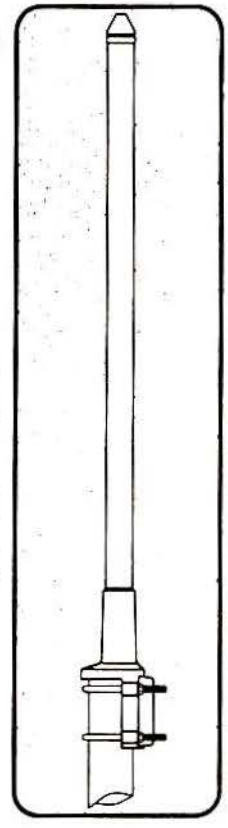
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Portable tower offers swift setup capability

Steel wire wraps a triangular-shaped shaft as it forms and rises vertically from three trailer-mounted spools. Computer-controlled winches reel cable through guy anchors and keep the tower straight.

By John W. Hughes

One portable tower technology is capable of extending towers as high as 300 feet in 30 minutes. (At present, 100-foot and 150-foot models are in production.) A tower can be erected by one person with this method, but safety considerations for operating such machinery call for at least one operator and one observer.

How it works

Three bands of spring steel form the tower as they emerge from clutch-driven, trailer-mounted spools. An ejector guides the bands, bringing them to together to form the triangular shaft. As the shaft rises, the ejector wraps it with galvanized steel cable and binds the bands together. The tower rises at 10 feet per minute.

A computerized guy-wire system relies on computer-controlled winches to deliver the right amount of tension to the three guy-anchor points. The tower mast is secured at specific, programmed intervals as it extends, ensuring maximum stability. Three winches are used for each guy level.

The system is impervious to icing, heavy rain and extreme temperatures.

The winches are on the tower platform—usually a trailer—and the cables pull through the anchor points and rise with the tower. The computer constantly measures guy-wire length and tension. It compensates for changes through the winches and maintains correct guy-wire lengths to keep the tower straight as it deploys or retracts.

The computer automatically makes all the measurements and keeps the tower on course, so the tower can be put up by one person.

The computer stops the tower's ascent at programmed intervals. All the operator must do is to attach the next set of guy wires. Because of the guy-wire system design, the guy anchors can be placed at different ground elevations.

The tower can be erected in the dark without using lights because the computer regulates its ascent and keeps it on course by controlling guy-wire lengths. The system is impervious to icing, heavy rain and extreme temperatures.

The technology can be scaled to meet

Hughes is president of Rapid Deployment Towers, Azle, TX. The company manufactures RapUp towers that use the technology described in this article.



A half-ton truck pulls a trailer bearing the portable tower. Though a 1-ton truck is recommended for this 150-foot tower, the truck in the picture has pulled the tower more than 10,000 miles.



An operator readies the tower deployment process using the computer that controls guy-wire tension.



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Winches aboard the trailer keep the cable under tension as it unreels through the guy anchors to rise with the tower.

various heights, equipment loads and winds. Programs requiring 300 feet with 8-foot dishes are proposed.

The original idea

Henry McGinnis, a Fort Worth, TX, structural engineer, developed the tower after discussing shortcomings of other portable tower technology with foreign military officials. The officials wanted a portable communications tower to use in the battlefield. "They had had quite a bit of trouble with telescoping towers," McGinnis explained.

After thinking about the problem for a month, McGinnis had an idea to use three pieces of flexible steel configured in a triangle to take advantage of that geometrical configuration's inherent strength. He envisioned wrapping the extended mast with cable to keep the bands together, thus maintaining its strength.

The next day he purchased three 1-inch-wide tape measures and a spool of wire. "By Saturday afternoon, I had a working tower model," McGinnis said.

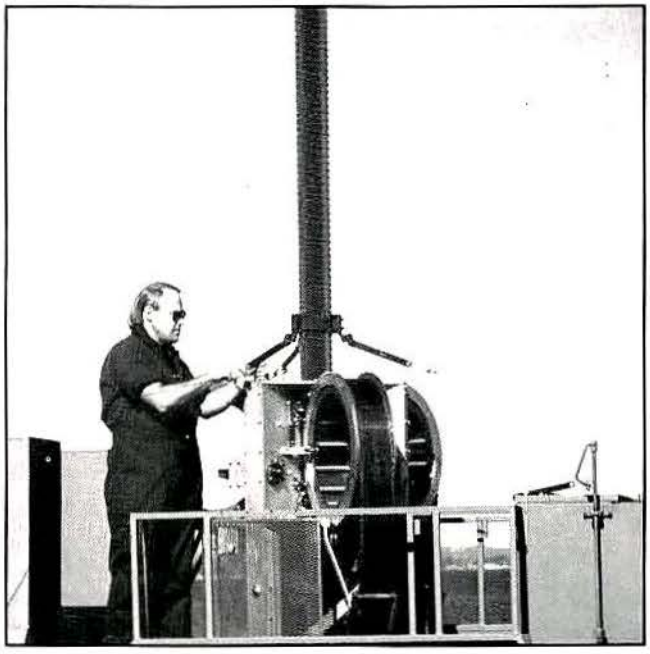
The current tower being marketed evolved from the tape-measure model. Perhaps the most important development is the guy-wire system. The computer guy-wire system is a byproduct of the tower project research and development. It offers built-in reliability.

Applications

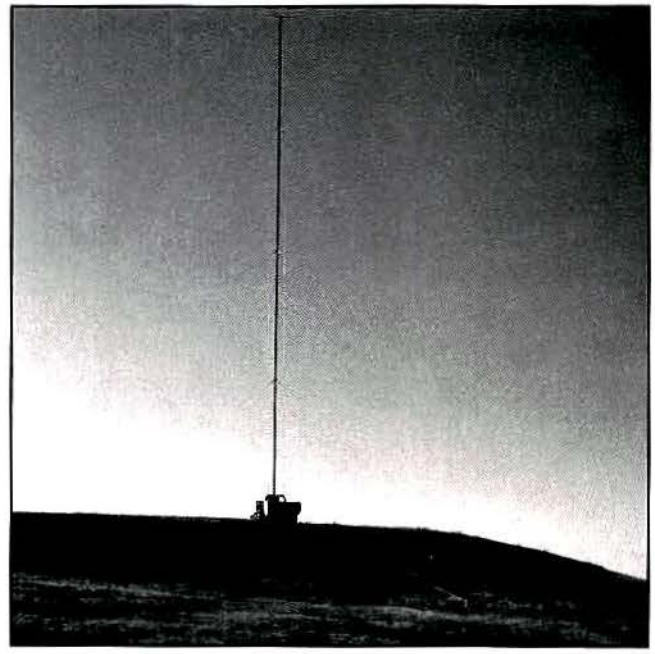
Uses include emergency communications during and after disasters; the remote broadcast of news and sporting events; and military applications. The tower supports communications antennas, microwave antennas, cameras and other instruments.

The tower normally mounts on a trailer. Because it is self-contained, the system mounts on nearly any permanent or mobile platform. Tower models are marketed for four heights: 100 feet, 150 feet, 225 feet and 300 feet. In one installation, the 150-foot tower, extended to 100 feet, withstood a 106 mph wind-loading with the equivalent of a 350-pound payload and 17.5-square-foot solid dish.

The 150-foot model's mast weighs less than 600 pounds. The whole system, mounted on an 8-foot × 16-foot trailer, weighs less than 8,000 pounds, including a 12kW generator, trailer, tower and guy-wire system.



An operator connects guy-wire collars to the shaft as the tower ascends.



The erect tower stands at 150 feet. The computer-controlled guy-wire system compensates for uneven ground.

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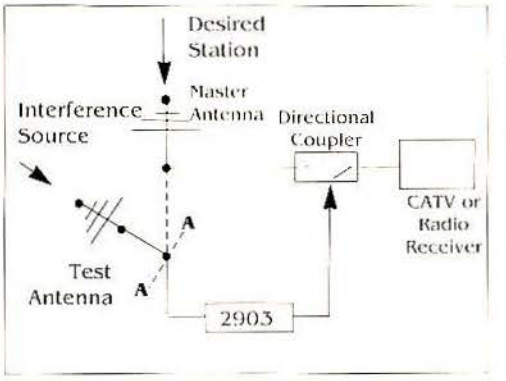
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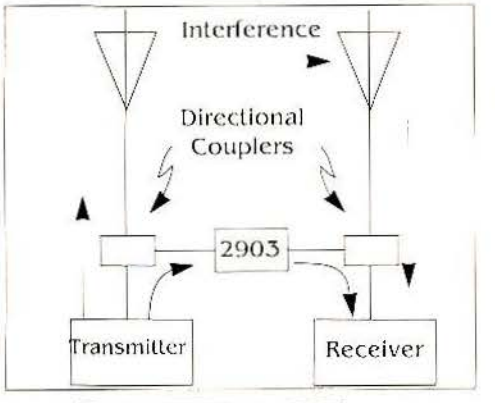
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Symposium focuses on wireless communications

What wireless communications services are emerging? Are you familiar with the history of land mobile and personal communications? What is happening with personal communications networks?

The Wireless Personal Communications symposium June 3-5 in Blacksburg, VA, will address these and other pertinent topics. The symposium will be at The Donaldson Brown Center for Continuing Education at Virginia Tech. It is jointly sponsored by the university's Mobile & Portable Radio Research Group (MPRG) and its division of Continuing Education, and IEEE's Communications Society and Vehicular Technology Society.

The three-day event costs $185, and proceeds will fund MPRG undergraduate and graduate studies.

For more information about the symposium, telephone Jack Lilly at Donaldson Brown Center, phone: 703-231-5182. The registration deadline is May 6, and registration is limited.

Qualcomm inks pacts with Motorola, Nokia

Motorola, Schaumburg, IL, and Qualcomm, San Diego, will explore and develop products jointly under terms of an agreement involving code division multiple access (CDMA) technology. CDMA, one of several technologies under investigation in the United States for use in cellular networks, may provide capacity, transmission quality and efficiency advantages.

Under an agreement Qualcomm signed with Nokia Mobile Phones, Largo, FL, Nokia can develop and market mobile telephones that use Qualcomm's CDMA technology.

Sigtone moves to Florida

Sigtone has moved its office from Huntington Beach, CA, to Maitland, FL. The company may be reached at 225 S. Swoope Ave., Suite 105, Maitland, FL 32751; phone: 407-628-4828.

Edward S. Mathieu, formerly general manager of Philips Telecom, is Sigtone vice president and general manager.

Microlog buys Genesis

Microlog, Germantown, MD, subject to California approval will purchase voice mail systems manufacturer Genesis Electronics, Rancho Cordova, CA. A combination of cash and stock will satisfy the purchase price. Stockholders of Genesis will receive 675,000 shares of Microlog stock and $500,000 cash less certain adjustments.

Microlog designs and markets voice processing systems and is publicly held. At conclusion of the agreement, Genesis will be operated as a wholly owned subsidiary of Microlog.

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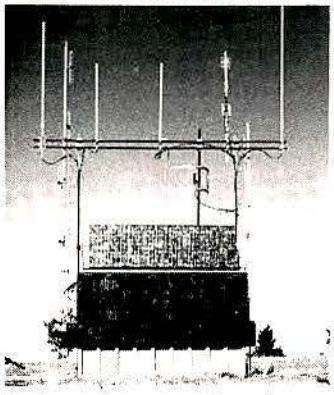
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NABER committee challenges unlicensed radio operation

The National Association of Business and Educational Radio (NABER) is forming a committee about unlicensed radio operation. The committee's purpose is to identify and evaluate potential regulatory, legislative and marketplace initiatives to curb unlicensed operation.

Unfair advantage

"Unlicensed operation has reached an intolerable level," said F.G. "Spike" Fuson, the association's chairman. Fuson is vice president of Communications Engineering, Las Vegas. "There are land mobile dealers who are not licensing their user customers solely for the purpose of gaining an unfair advantage by offering users faster on-air operations and lower prices. If they continue to break the FCC's rules, these unscrupulous dealers will destroy the spectrum. NABER is not going to sit by and let that happen."

NABER represents licensees in the Business Radio Service, private land mobile radio service whose frequencies are available to individuals and entities engaged in commercial enterprises. Certain educational institutions and members of the clergy are eligible for business radio licenses, too.

Theft of service

Mary Kjorvestad of Empire Mobile Communications, Houston, serves as chairman of the Association of Mobile Radio Dealers (AMRD), a NABER membership section. She said unlicensed radio users cause a problem through the theft of community repeater airtime, as well as causing interference. She said manufacturers may be in the best position to inform the public about licensing requirements by placing a warning label on radios they make.

"There are fewer manufacturers than there are radio system operators and sales people," she explained. "The closer to the point of manufacture that the information is disseminated, the fewer people have to be involved in the process."

She said as many as half of the radio users on the UHF and VHF bands may not know they have to have a license. "They can buy the radios anywhere, and they may happen to activate the radios on someone else's repeater system." Kjorvestad said the theft of service represented by using someone's repeater without a license and without permission is a felony. She said *proving* such a case requires a lot of time and the use of expensive equipment.

NABER's role

Richard McAdoo, NABER's marketing director, said the association's volunteer leaders and staff members have been talking primarily with larger dealers and radio users. He described unlicensed operation as a two-edged sword. "Dealers who are not following through in licensing their customers have a competitive advantage," he said. "In addition, the unlicensed operation is creating chaos with spectrum management."

McAdoo said the association is asking dealers to suggest solutions that make sense to them, "operating in the real world." Then, he said, the association would ask for changes in FCC rules or federal law to make it easier for the FCC to take action against unlicensed operation.

NABER membership services and communications director John Sherlock said the association effort began when six or seven members expressed an interest. "Unlicensed operation has reached such a high level that it is affecting their profits," Sherlock said. "They called on their association to do something about it. We are wide open to suggestions."

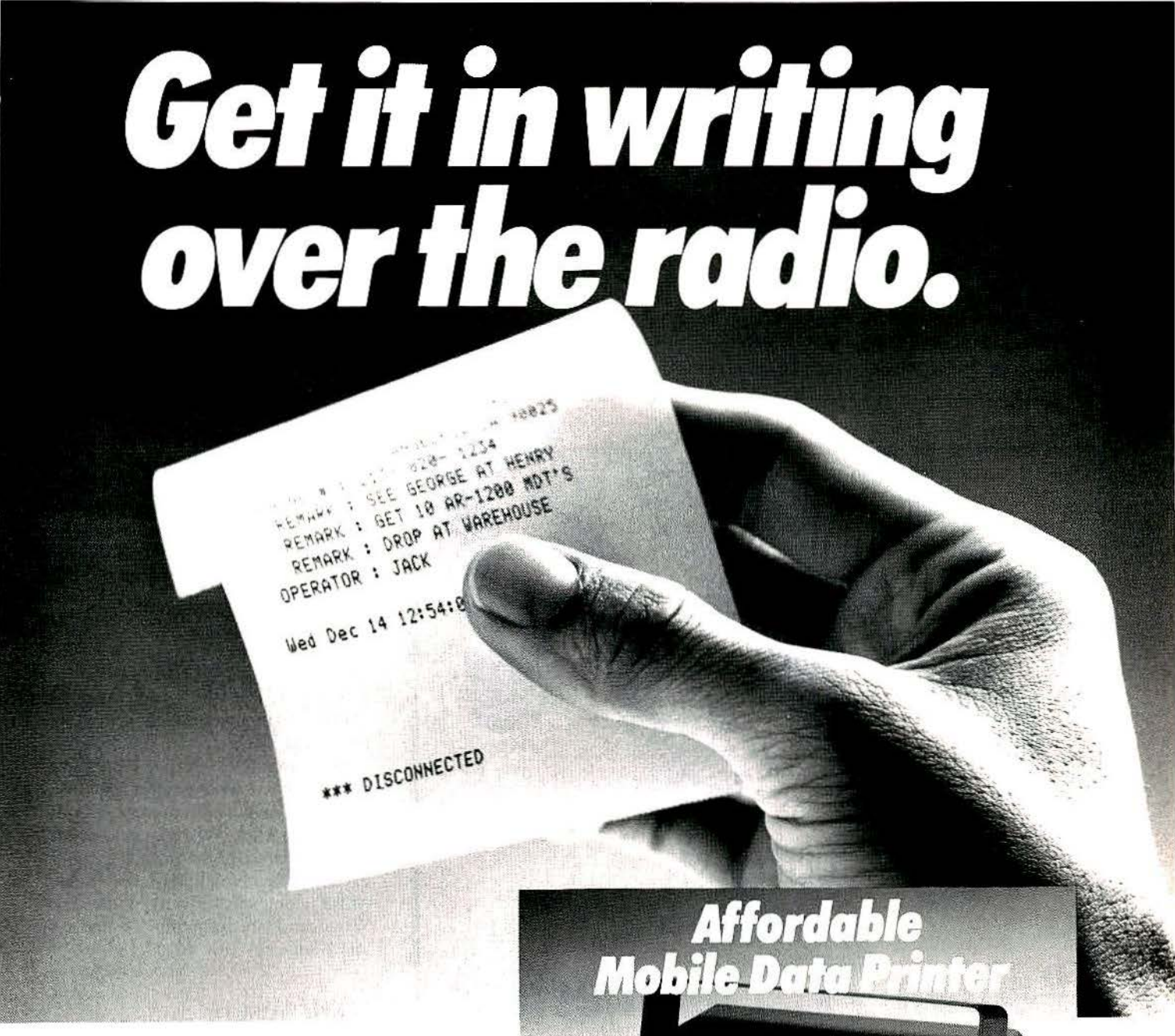
Sherlock said one suggestion is for the FCC to provide an incentive, "like an 'unlicensed operator hotline' where less-than-scrupulous types can be turned in, so the FCC can target its efforts."

He said the radio spectrum is such a fragile resource that NABER has to be aggressive and visible in whatever efforts it takes. "It is important for everyone to know this is getting attention. NABER plans to heighten awareness."

The committee on unlicensed operation, Sherlock said, "offers an opportunity for members to work creatively to come up with solutions in the face of the FCC's limited budget."

Dealers who set up unlicensed radio

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Civil liberties group takes Motorola to court

The Massachusetts Civil Liberties Union Foundation has filed suit in Suffolk Superior Court in Boston against Motorola, Schaumburg, IL, and two of its subsidiaries in Massachusetts to stop the company from carrying out its new policy of random, without-cause urinalysis drug testing of all employees.

The policy calls for all employees, regardless of the nature of their work or job performance, to submit to random testing. The policy further states that employees who do not cooperate with the drug testing will be terminated.

The Civil Liberties Union has brought the suit on behalf of two Motorola employees who work for the company in Massachusetts and who are subject to mandatory testing in 1991. The complaint asserts that the drug testing policy violates the rights of the employees under the Massachusetts Civil Rights Act, the Privacy Act and the Massachusetts Constitution.

The suit alleges that urinalysis testing produces false positive and false negative results and fails to detect recent ingestion of drugs.

The plaintiffs are requesting the court to declare the policy unconstitutional and to issue an injunction preventing Motorola and its subsidiaries in Massachusetts from incorporating the drug testing program in the state.



Circle (71) on Fast Fact Card

Manufacturers reps change at Relm

Relm Communications, Indianapolis, has added a manufacturers representative and expanded another representatives' territory. Assure Marketing N.W., Redmond, WA, will represent Relm in Alaska, Oregon, Washington, western Montana and northwestern Idaho. Relm expanded Southfield, MI-based Robert Milsk Company territory to include Wisconsin, northern Illinois, Indiana and Kentucky.

Kyodo West receives FCC OK for mobiles

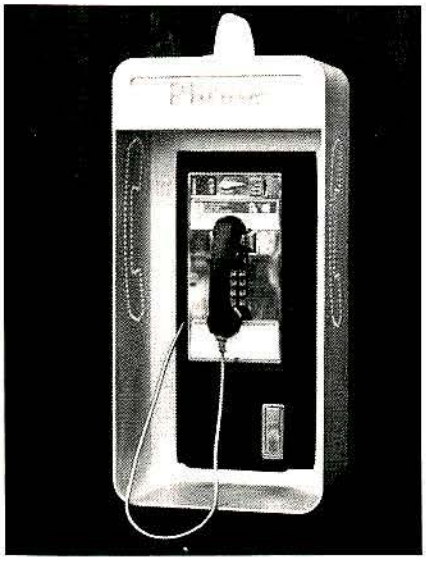
Kyodo West, Bridgeville, PA, has received FCC approval for two of its mobiles radios—the KG105 and KG107—marking its official entry into the U.S. marketplace. The firm's parent in Tokyo has been in business for more than 50 years.

The company plans long-term expansion of its U.S. facility and light manufacturing and assembly of various communications products on site.

Larsen appoints rep

Larsen Electronics, Vancouver, WA, has named W. A. Hendrickson Company as its New England sales representative. Hendrickson will cover Maine, Vermont, New Hampshire, Connecticut, Rhode Island and Massachusetts.

Public telephone houses CT-2 telepoint



A coin-operated public telephone developed by Advanced Cordless Technologies, Montville, NJ, houses a CT-2 (second-generation cordless telephone) telepoint. A telepoint is a two-way radio base station interconnected with the wireline telephone network.

CT-2 telephones are, in effect, two-way radios equipped with telephone dials that allow users to place phone calls when they are near a telepoint.

The Advanced Cordless combination public phone and telepoint handles as many as four CT-2 channels and the public phone line simultaneously.

HM Electronics opens Battery Systems Division

HM Electronics, San Diego, has formed a Battery Systems Division to make nickel-cadmium battery chargers and analyzer-conditioner products. "We will compete in the communications and industrial charger and accessory business and in the OEM battery pack business," said Don Kutz, HM Electronics' executive vice president, who also serves as the new division's general manager. "We do not intend to compete in the communications and industrial after-market battery pack business."

The division is at 6675 Mesa Ridge Road, San Diego, CA 92121; telephone 619-458-1500 and 800-233-6868; fax 619-452-7207.

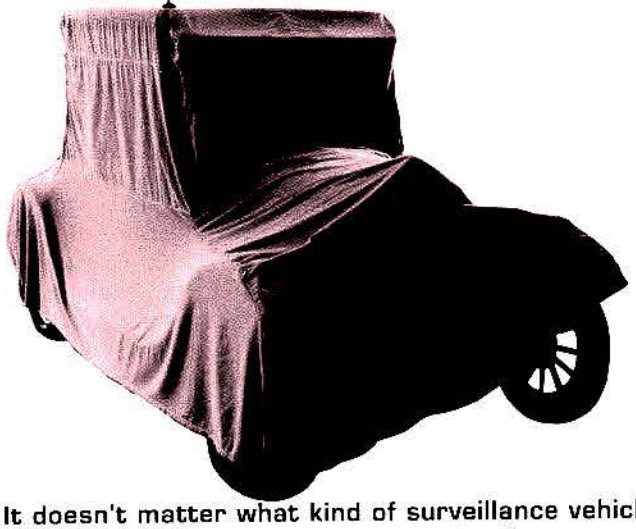
US CommStruct opens branch offices

US CommStruct, a communications construction company and shelter manufacturer in Vestal, NY, is expanding its office and hiring more employees. Branch offices will be opened in Plainfield, NJ; Atlanta; and Yorba Linda, CA. Each office will be responsible for local coordination and construction.

SkyTel reaps bank financing for nationwide paging growth

SkyTel, Washington, DC, has garnered $30 million in financing from Chemical Bank of New York and Credit Lyonnais' New York branch. The funding will buy additional pagers and expand SkyTel's nationwide paging system. SkyTel markets SkyPager nationwide paging services.

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Western Multiplex moves

Western Multiplex, Belmont, CA, has moved. The company may be reached at 310 Harbor Blvd., Belmont, CA 94002; phone: 415-592-8832. Fax: 415-592-4249.

Motorola forms land mobile, paging-telepoint groups

Motorola, Schaumburg, IL, has divided its Communications Sector into a "Land Mobile Products Sector" and "Paging and Telepoint Systems Group."

The land mobile sector, lead by Morton L. Topfer as president and general manager, includes trunked SMR systems and private systems. The new paging and telepoint group directed by Robert L. Growney as senior vice president and general manager includes pagers, paging system equipment and telepoint products.

ARDIS signs pact with software company

ARDIS, a partnership of IBM and Motorola based in Lincolnshire, IL, has signed an agreement with Radio Frequency Data Network Systems, Hinsdale, IL, for the delivery of software compatible with the ARDIS nationwide radio data network.

RF Data will design custom communications software for existing and future ARDIS customers. The company's services include software design and implementation for business information systems that rely on RF devices. Terms of the deal were undisclosed.

Radio business, cellular firm team up for expanded service

Cattron Communications, Sharpsville, PA, a two-way radio business, has joined forces with Wilcom-Cellular One, Youngstown, OH, to offer customers enhanced service and technical support for radio systems.

Wilcom-Cellular One will continue to sell and install its two-way radio systems, and Cattron will provide technical, billing and customer service support to these customers. Cattron has three locations and maintains mobile service shops with FCC-certified field technicians for on-site repairs.

Cattron also will carry Wilcom-Cellular One's pagers and cellular phones, which can be purchased, rented or leased by users.

EIA reorganizes components group

The components group of the Electronic Industry Association (EIA), Washington, DC, has been restructured. The framework includes the formation of product-specific divisions and forums representing broad areas of common interest of members.

Created divisions include Capacitors; Resistors/Networks; Connectors and Interconnect Devices; Switches and Fuses; Filters and Delay Lines; Transformers and Inductors; Piezoelectric Devices; Relays; Sensors; Electronic Display and Tube; and Semiconductor Devices. Other divisions will be determined by the membership.

Forums have been established for distribution, small business, and sales and marketing. Others will be added as necessary.

UTC files comments on WARC '92 proposals

The Utilities Telecommunications Council, Washington, DC, has filed comments to the FCC about spectrum allocation proposals for the 1992 World Administrative Radio Conference (WARC).

The UTC opposes the proposal of reallocation of the 7,200kHz-to-7,525kHz band to the high frequency (HF) broadcast service. In its comments, the council said fixed services, long-distance emergency communications in particular, provide important public safety benefits and should be favored over information and entertainment services.

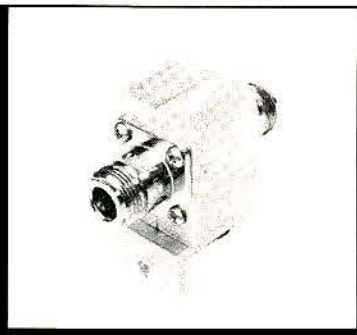
The council supports the FCC's proposal to retain co-primary allocation in Region 2 for fixed and mobile services. It also favors the conclusion that an exclusive allocation for land mobile services in the 1,710MHz-to-2,500MHz band is not in the best interest of the United States.

In other opposition, the UTC contests an allocation for a Broadcasting-Satellite Service (BBS). The council favors a reallocation of the UHF-TV spectrum.



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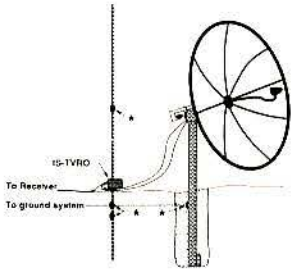
Grounding & Lightning Solutions



COAX TO 6 GHz



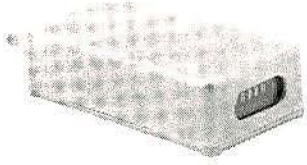
BROADCAST & MILITARY TO 50 KW



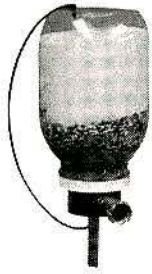
TVRO



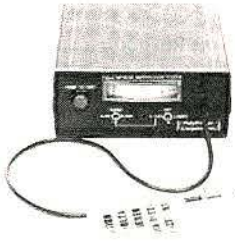
3ø POWER TO 480 VAC



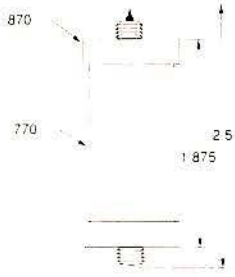
STRIKE COUNTERS TOWER/POWER/PHONE



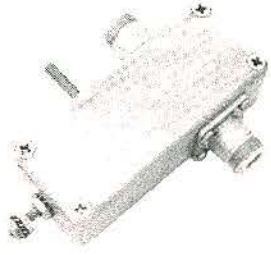
CHEMICAL GROUND SYSTEMS



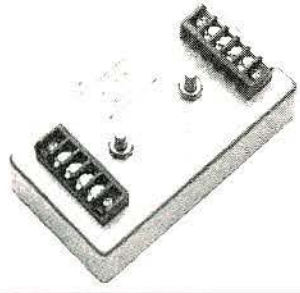
BREAKDOWN TESTERS



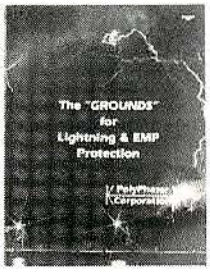
GAS TUBES TO 100 KA



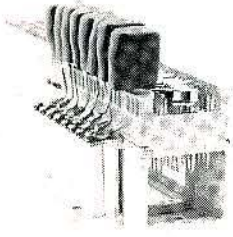
4 TO 23 GHz MICROWAVE DOWNCONVERTERS



T-1 (TO DS-3 RATES)



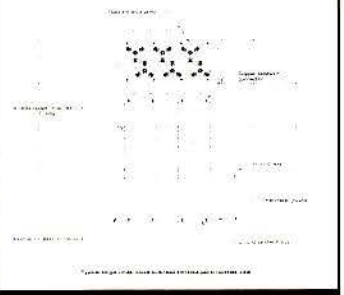
VIDEO & TUTORIAL BOOK



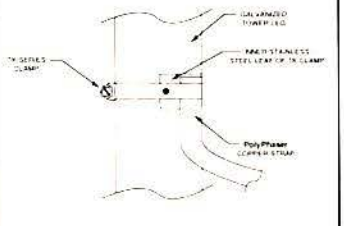
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Tekk forms data division

Tekk, Kansas City, has formed Tekk Data Division. The formation marks Tekk's entry into data communications products. The company plans to unveil telemetry radios and a data 4,800 baud polling system. A 4,800 baud-9,600 baud stand-alone modem for use with radios will be available soon.

RF Industries commences 'character' ad campaign

RF Industries, San Diego, has implemented an advertising campaign that features "Professor Connector" as the spokesman for the coaxial connector division of the company and "Link the Cat" as the representative of the Neulink telemetry division.

Consumers laud GE cellular phones

Financial World magazine readers have selected GE cellular phones manufactured by Ericsson GE Mobile Communications, Lynchburg, VA, as the "best" in the magazine's annual "Best of Everything" survey. Approximately 500,000 readers were asked to rate their choices of top brand names products by indicating the best and worst quality of the goods or services.

PacTel restructures, increases wireless focus

PacTel, San Francisco, is placing a greater focus on its wireless communications business and has reorganized its operations with personnel changes. The move will reduce overhead, as well as place a larger emphasis on wireless communications. PacTel is the holding company for PacTel Cellular, PacTel Paging, PacTel Cable, PacTel Teletrac, PacTel Business Systems, PacTel Properties and Pacific Telesis International.

Subscriber Computing nets license pact with PageNet

Subscriber Computing, Irvine, CA, and Paging Network, Plano, TX, have reached a software license agreement that allows PageNet to use Subscriber Computing's Paging Resource Manager system to support its personal paging operations nationwide.

The system will be installed at PageNet's integrated software modules, terminal interfaces and voice mail terminals. PageNet is the second largest radio common carrier in the United States with more than 500,000 pagers in use nationwide.

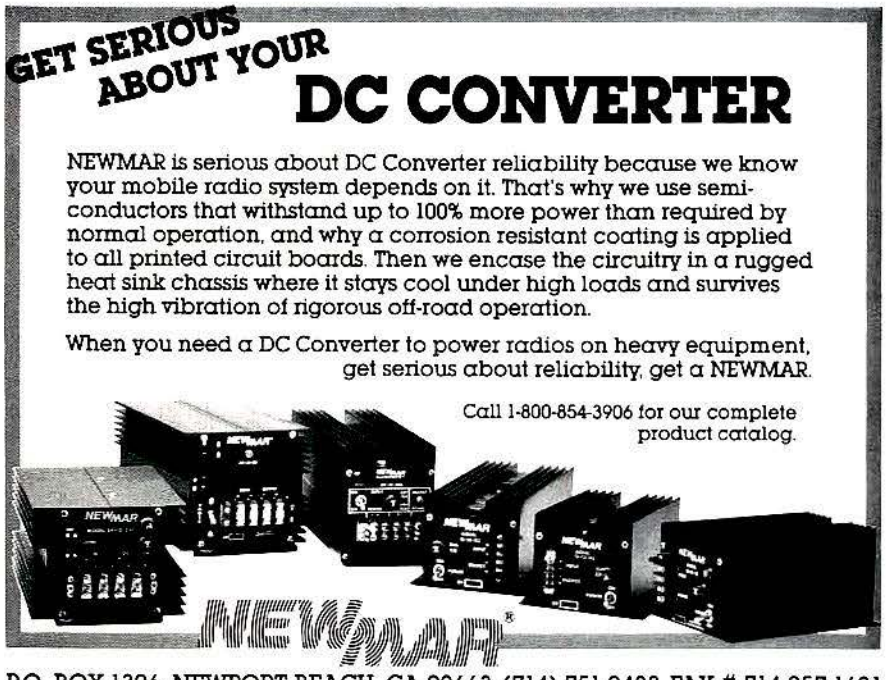
Motorola hand-held reaps second Japanese award

Motorola's MicroTAC cellular telephone has received the Japanese 1990 Ministry of International Trade and Industry Award for foreign good product design. Motorola, Schaumburg, IL, previously won Japanese recognition for its hand-held.

Seminar covers data communications

"Data Communications Systems, A Non-Technical Introduction" is a three-day seminar offered by the Center for Advanced Professional Development, Santa Ana, CA. The seminar covers developing, using and evaluating a data communications system.

The registration fee is $795, which includes the course workbook, and multiple registration discounts apply. For registration or more information on seminar dates and locations, contact the center at 714-261-0240.





O'Connell returns to Scientific Dimensions

Joe O'Connell Sr. has come out of retirement to return to Scientific Dimensions, Albuquerque, NM, as a consultant for the company's research, new product development and engineering division. In 1984, he sold the company to his son, Joe O'Connell Jr. The following year he sold his precision sheetmetal facility and retired.

"Retirement is not what it is cracked up to be," O'Connell said. "Work is fulfilling. I derive more pleasure from creating and problem-solving than playing golf and traveling to the Caribbean."

O'Connell has developed four new products that were introduced in March: a mobile data terminal mount; a universal transportable phone mount; a facsimile machine mount; and a laptop computer mount.

Antenna Specialists acquires interest in electronics firm

Antenna Specialists, Cleveland, has acquired a majority interest in Grayson Electronics, which will operate as an independent subsidiary. Grayson designs 900MHz transmitters and receivers, linear RF power amplifiers and pre-amps, mobile and portable repeater systems, and tone signaling devices.

Glenayre Electronics opens Voice Systems Division

Glenayre Electronics, Vancouver, British Columbia, has formed a Voice Systems Division to develop, market and service voice processing products manufactured by the company. The division will be based in Atlanta, currently the home of the company's Glenayre-Atlanta operation. Dan Case has been named senior vice president and general manager of the new division.

Power Pak names Midwest representative

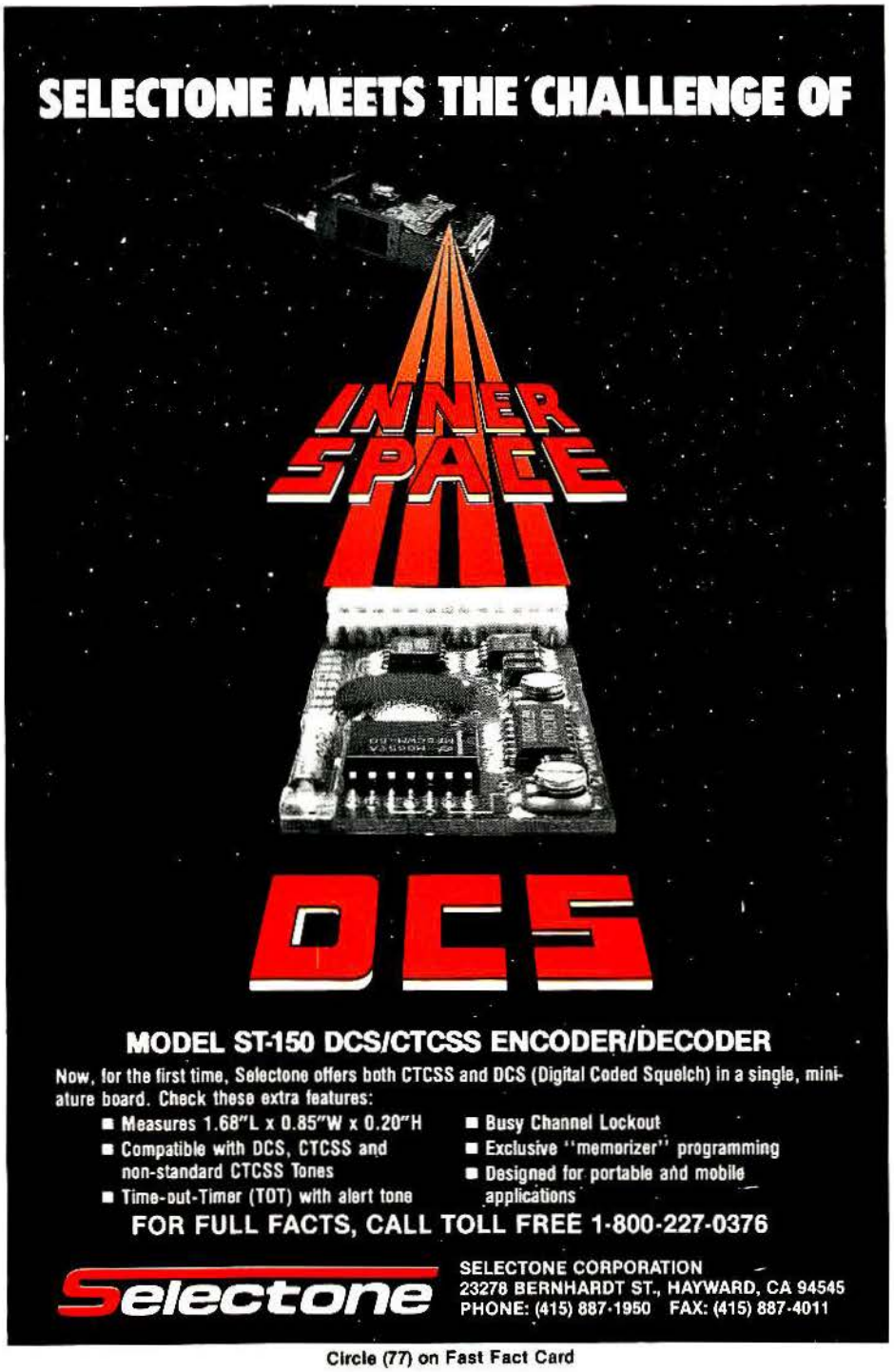
Power Pak, Morton Grove, IL, has selected Spectrum Sales to handle sales in Iowa, Kansas, Nebraska, Missouri and southern Illinois. The company has two offices: 3879 W. 95th St., Overland Park, KS 66206; and 47 Village Square Center, Ste. 43, Hazelwood, MO 63042.

Seiko invests in wristwatch pager company

Seiko has agreed to defer about $2 million in debt plus interest for AT&E, San Francisco, developer of the Receptor wristwatch pager. In January, AT&E released 40% of its workforce. Most of the layoffs occurred at AT&E Laboratories in Portland. Previous layoffs occurred in October.

It is reported that, under the agreement, Seiko has an exclusive right to manufacture and distribute the Receptor wristwatch pager under its own name in Asia and a non-exclusive right to distribute pagers in the United States.

The agreement includes a $5 million loan.



Circle (77) on Fast Fact Card

Council begins planning for technician recognition program

Clark Hinds, a member of the Association of Communications Technicians (ACT) volunteer leadership council, said the council has begun a process that is expected to establish a technician recognition program.

He said Federal Express, where he works as the senior manager of the Telecommunications Repair Center in Memphis has a recognition program for its service technicians. The company has permitted him to use its program as a model for the ACT recognition program.

"We look at performance, professionalism, customer satisfaction, asset management and teamwork," Hinds said. "We break down each element into individual criteria. The key thing we are looking for is that the performance and the customer satisfaction be verifiable. I would like to hear from the customer base instead of just the employee's manager. Customer-supplier alignment is critical for any type of service operation."

Among other issues being considered are how often to make the award and when to begin the program.

Membership growth

The technician recognition program is one of several items the council is considering as part of efforts to increase the association membership.

"We had discussed the possibility of student memberships," Hinds said, "but there were some financial questions to be answered. Student memberships are a good way to bring new people into the organization."

Information

For information about ACT and technician certification, call 800-759-0300. Ask for 'technician services.'

Technician certification examinations will be offered at 120 sites in 43 states on the following schedule:

TEST DATES	REGISTRATION DEADLINE
May 17 and 18	April 12
June 28 and 29	May 24

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Fleet Call obtains OK to build SMR system under present rules

Most of Fleet Call's proposal to waive certain FCC rules to construct low-power, multisite digital radio communications facilities on channels in the six largest U.S. markets has been denied as unnecessary by the commission. The FCC ruled that current regulations allow Fleet Call to carry out its plan. The enhanced specialized mobile radio service (ESMR) proposal had been pending at the FCC since April 1990, and the SMR community, as well as the entire land mobile communications industry, had waited anxiously for its outcome.

The cellular telephone industry's opposition to the waiver request had attracted Congressional support. But the opposition is undermined by the FCC decision. Waiver grants and rulemaking proceedings can be protested, delayed and perhaps defeated, but it is much more difficult to block an endeavor permitted under current rules.

In the action, the FCC granted Fleet Call a waiver for a five-year construction period; the rules stipulate a one-year time frame. Fleet Call had not requested a waiver on the one-year construction period, but the FCC deemed it necessary, contending that sizable, sophisticated systems cannot be constructed in a year.

A blanket license for each of the individual wide-area systems in New York, Los Angeles, Chicago, San Francisco, Dallas and Houston was denied by the commission. Fleet Call made 100 acquisitions in these six markets and owns and operates approximately 1,700 channels at 800MHz and 400 channels at 900MHz.

"The FCC rules do not restrict how many SMR frequencies you have once you meet certain basic loading criteria," said Morgan O'Brien, chairman of Fleet Call, Bloomington, NJ, at a fall meeting. "Our observation in 1987 was that in these markets, which are the most heavily congested, the opportunity was right for consolidation."

The system will incorporate high-speed digital transmission, frequency reuse, multiple low-power stations and other technologies. "At present, there are in excess of 1-million units operating on SMR services nationwide, mostly in the 800MHz band," O'Brien continued.

One of the requests Fleet Call was denied involved a waiver of the prohibition of short-spaced SMR base stations within 70 miles of each other. The commission will continue to require a waiver request with engineering data, or at least for now. Interestingly enough, the commission is considering an amendment to its rules to permit short-spaced base stations within 70 miles of each other on the basis of an engineering demonstration that there would be no interference. A waiver request would be unnecessary.

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Circle (80) on Fast Fact Card

Studies, applications, legislation affect spectrum availability

Several proceedings taking place in Washington, DC, will affect spectrum availability in 1991 and beyond, Clifford Bean told an audience at a trade association meeting near Tampa, FL. Bean is a director of Arthur D. Little, a Cambridge, MA, consulting business.

Among the proceedings are:

• *NTIA study.* "The National Telecommunications and Information Agency spectrum requirements study examines all society's needs for radio spectrum to meet the future communication needs of the entire U.S. public."

• *WARC '92.* "The coming 1992 World Administrative Radio Conference signals a reconsideration of global spectrum allocations and the positions that the United States will take as a part of the North and South American region with respect to other regions of the world," Bean said. "The conference needs to hear a strong, articulate voice that presents the top priority needs of the U.S. public. Preparations going on now will influence in the long term how certain allocations will be made in the short term in the context of these preparations."

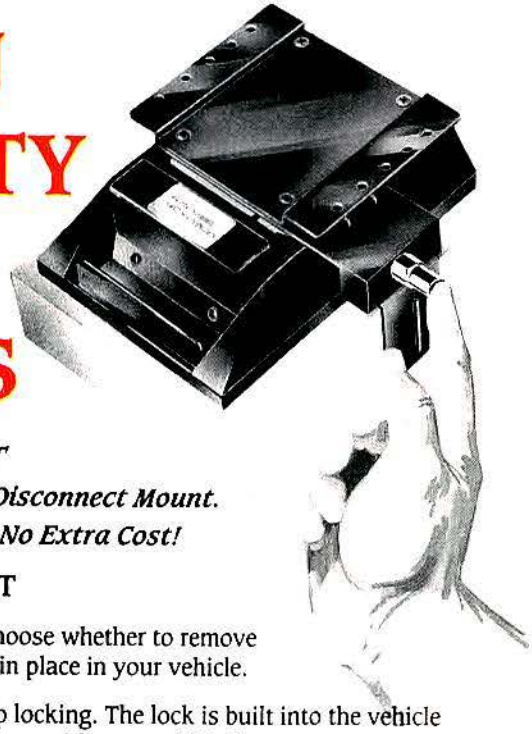
• *Dingell Bill.* "If the 200MHz that is being considered or if any portion of that spectrum gets allocated to land mobile services, it certainly will provide new opportunities." (The "Dingell Bill" is HR 2965, introduced by Rep. John Dingell [D-MI].)

• *PCN applications.* "We now are seeing a large number of so-called PCN applications. Some of them are called CT-2, (second-generation cordless telephone), modeled after European licenses granted," according to Bean. "We're also seeing other personal communications network applications vying for radio spectrum space with some receiving licenses for experimental operations."

• *HDTV.* "A number of high-definition TV initiatives are in progress," Bean said. "These initiatives well could chew up large chunks of radio spectrum if successfully promulgated."

• *Air-to-ground.* "Some actions have been taken with respect to granting multiple air-to-ground licenses, indicating the commission's interest in encouraging competition in the mobile communications marketplace," Bean said.

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ATA Services wins contract to offer FCC database access

Under terms of a contract with the FCC, ATA Services has become the sole provider of on-line access for portions of the non-government Master Frequency Database. A subscriber information package may be requested by telephone or mail from ATA's client services manager, Sue Czarnetzky. ATA Services is at 2200 Mill Road, Alexandria, VA 22314; phone: 703-838-1901.

Laser printer produces radio license documents

The FCC has upgraded the printing of radio licenses with the use of a laser printer. Previously, licenses were printed through carbon paper in sealed envelopes, a process that sometimes produced smudged type, making the document illegible.

The new license documents boast a crisp, clear print.

Along with land mobile radio licenses, the FCC is enclosing copies of FCC Form 715A, "High Intensity Obstruction Lighting Specifications For Antenna Structures," Form 715, "Obstruction Marking and Lighting Specifications for Antenna Structures" and license conditions and administrative notes.

FCC Private Radio Bureau chief Ralph A. Haller displayed samples of the previous and current license documents at a trade association meeting in October.



FCC Private Radio Bureau chief Ralph A. Haller displays a carbon-printed land mobile radio license that was damaged in mailing and returned to the commission. Printing was done through a sealed envelope, blurring the lettering.



Haller shows one of the new laser-printed licenses. Laser-printing produces clear, crisp type that improves legibility and avoids carbon smudges that handling sometimes caused with the previous printing method.

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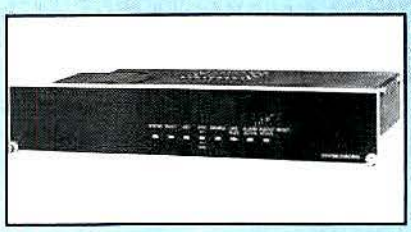
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Circle (82) on Fast Fact Card

Readers' choice

Of all the new products and services in the August 1990 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Simulcast controller makes maintenance automatic

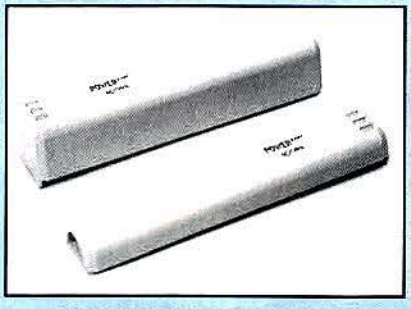


The SimulComm system controller provides automatic frequency locking, over-the-air optimal phase delay and audio gain, and automatic transmitter alarms for simulcast paging, two-way radio and mobile radio systems. The controller is available from **Glenayre** and controls as many as 255 transmitters in as many as 255 zones. Transmitter site alarms are reported to an operator console via alpha page.

Circle (284) on Fast Fact Card

Rechargeable battery packs increase portable talk time

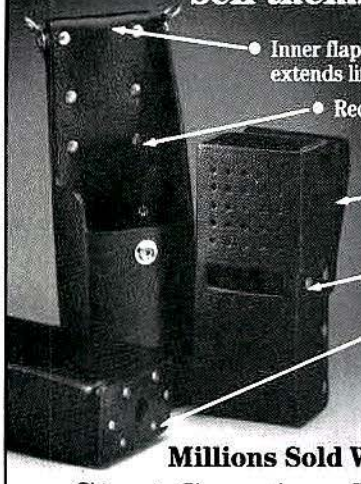
Power Up battery packs increase talk time for cellular portable telephones as much as 30% over other batteries similar in size. Model MBP1100 offers 7.5V and 1,100mAh. Model MBP2200 is rated 7.5V and 2,200mAh. The **Ora Electronics** NiCd battery packs fit Motorola 8000/9000 series portables. Packs for other models are available.



Circle (286) on Fast Fact Card

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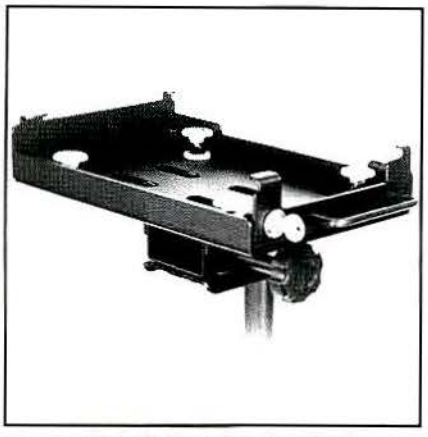
Wireless earphone suits covert operations

The Collarset communications unit from **Television Equipment Associates** provides covert communications between undercover officers. Components include a mic that installs under a user's shirt or collar; a wireless receiver earphone that inserts into the user's ear canal; a PTT switch that fits in a pocket; and a connector that plugs into the user's radio. The unit is easy to install.

Circle (285) on Fast Fact Card

Mounting head fits Grid 1500 laptop computer

Gamber-Johnson's DS-15 mount head is designed to fit the Grid 1500 series laptop computers and fits any of the company's DS modular mount bases. It includes a sliding drawer movement with a handle for quick installation and removal. A key lock on the drawer is standard, and tamper-resistant hardware is optional.



Circle (287) on Fast Fact Card

Station encoders include transmit indicators



Station encoders from **CPI Communications** have sloped fronts for easy key identification, non-skid rubber feet and transmit indicators. Models include the 780-SE DTMF encoder and model 765/766-SE 2,805Hz/1,500Hz pulse encoders in a station type housing. The pulse versions offer 10pps encoding, 16-digit memory, last-number redial and relay keeping.

Circle (315) on Fast Fact Card

PROVEN PERFORMERS - ECONOMY PRICED

Rural Telephone System

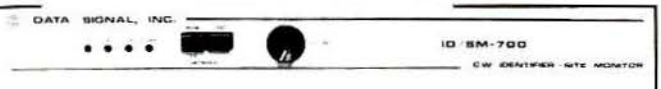
Provides Wireless Phone Service



Low-cost alternative to wireline service. Provides full-duplex remote telephone service compatible with DTMF or rotary exchanges. The remote terminal provides ring voltage to activate any standard telephone set bell. Plugs into virtually any repeater system.

Model RTS-25 $499.00

Automatic Morse Code Identifier and Site Monitor



Microcomputer-controlled and totally field programmable, including the ID and all timing parameters. Provides inhibit inputs and an inhibit-release delay to prevent traffic interference. Meets all FCC requirements. The site monitor feature enables up to six site functions to be continuously monitored and to provide status information to a remote decoder.

Model ID/SM-700 $159.00

DATA SIGNAL INCORPORATED

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Albany, Georgia 31708

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Circle (85) on Fast Fact Card



Alexander produces the most complete line of replacement batteries for today's portable communications equipment including models from Motorola, GE, Icom, Shinwa and Standard radios.

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GET A CLEAR PICTURE OF:

QUALITY Alexander Batteries quality is unsurpassed. Sanyo and Panasonic cells are used for proven performance and superior talk-times.

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SERVICE Alexander products are backed by a full one year warranty on parts and labor and a 30-day money-back guarantee that Alexander products will live up to your customers' specifications.

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With these features and competitive pricing, an Alexander battery program is clearly the one for you. Here's one more reason:

A SPECIAL DEALER OFFER

Purchase $500 of Alexander two-way or cellular batteries and receive this FREE portable TV. Manufacturer's suggested retail price – $169.95, as advertised in major newspapers and magazines across the country.

Valid on orders received prior to May 31, 1991. While quantities last. Some restrictions may apply. Must mention this ad when placing order.



The Bentley Deluxe 4.5" Portable TV

- Compact design.
- Weighs just three pounds.
- Uses 9 "D" cell batteries (included).
- 82-channel receiver.
- VHF/UHF electronic tuner.
- Eight-section antenna.
- Built-in tinted sunscreen and sunshade.

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Alexander Batteries

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Circle (86) on Fast Fact Card

New products

Wideband portables enal 16 or 99 channels

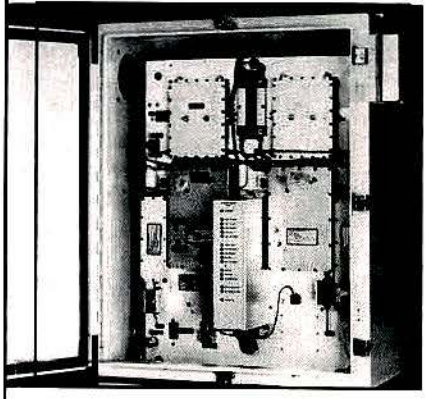


Two rugged wideband portables military specs 810C and D. The l **land LMR** radios, model 70-195 ' and model 70-295 UHF, come w 600mAh battery, and RF output p is 5W, switchable to 2W. Channe pacity is 16 or 99 channels, prog mable by group. CTCSS and DC built in and programmable by cha at random.

Circle (316) on Fast Fact Card

BETRS repeater system provides 77dB gain

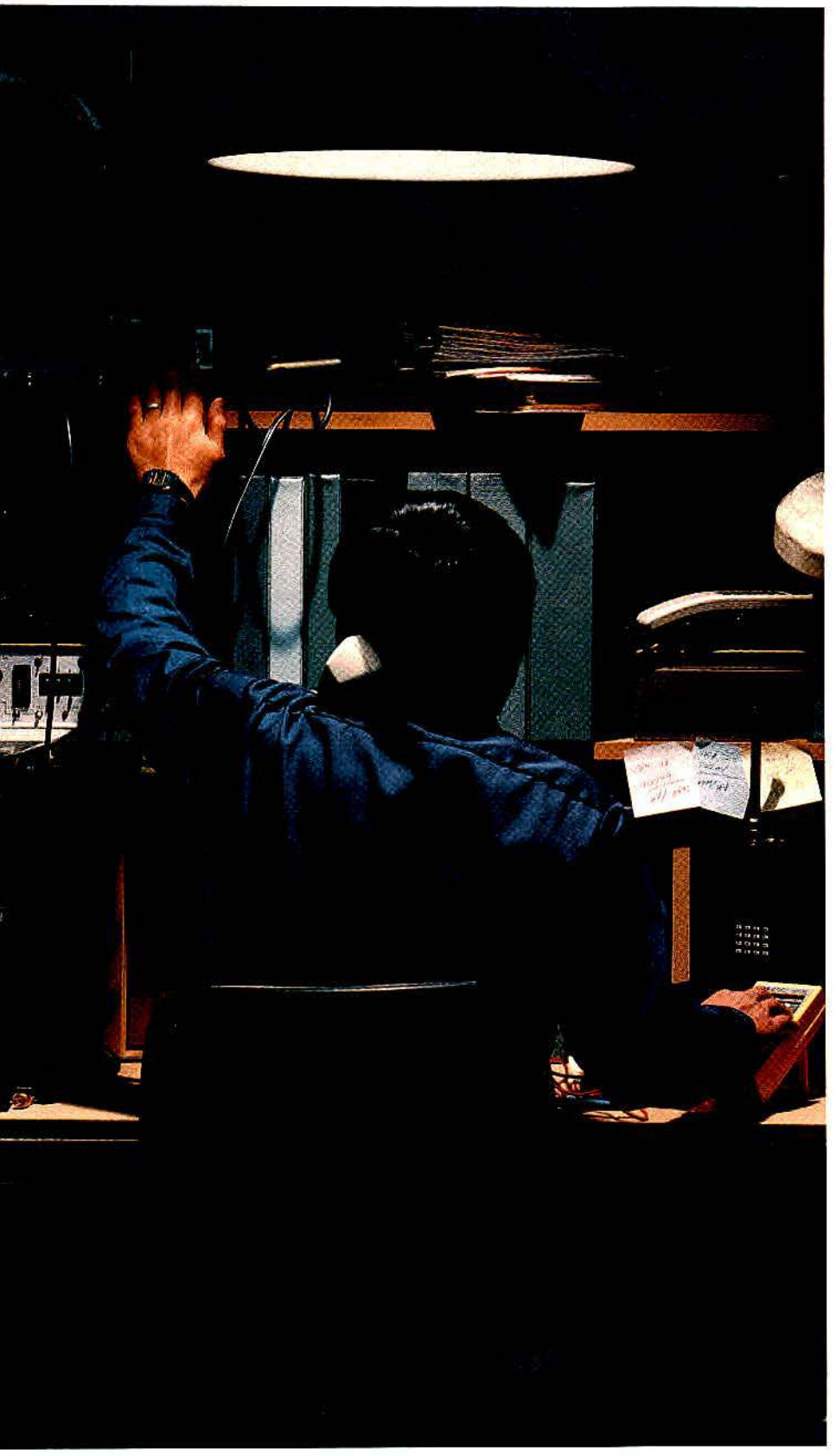
The SFR-450 BETRS repeater sy provides 77dB gain across a 670 bandwidth and amplifies all 26 av ble channels. Typical coverage for **Peninsula Engineering Group** rep er is 5 miles to 7 miles. The repe



system includes alarm circuitry, 6(power consumption and all-weatl housings.

Circle (267) on Fast Fact Card

When we talked to technicians about service monitors, they told us they were too busy to talk.



Now, the new HP 8920A solves test problems in less time, so you have more.



In radio testing, you have to work fast to keep up. And when it comes to working fast, the new HP 8920A RF Communications Test Set can put you way ahead. At a very affordable price.

It's ready to go when you are. Just connect your AM, FM, SSB or cellular radio to the HP 8920A to get receiver results. Push the TX key to automatically tune and measure transmitter frequency, power, deviation and audio power. Push another key for full duplex measurements.

And it goes wherever you need it. At only 35 pounds, the HP 8920A has all the precision troubleshooting tools you need in the shop or field. That includes an oscilloscope, duplex signal generator, AC/DC voltmeter and optional signaling encoder/decoder. You can add a spectrum analyzer with built-in tracking generator and RF probe to make short work of hard problems. And a built-in controller lets you automate routine tasks.

So, if test problems are tying you up, talk to HP. Call **1-800-752-0900,** and ask for **Ext. 2149.** We'll send you a free video that shows how fast the HP 8920A can give you more time.

There is a better way.

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New products

VHF mobile covers 24MHz frequency range



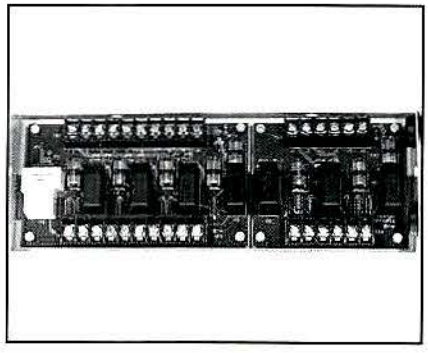
Model 70-1336 wideband FM mobile from **Midland LMR** offers adjustable output power of 15W to 30W. The VHF mobile covers a 24MHz frequency range at full rated specs without retuning. Features include built-in CTCSS and DCS, which are programmable by channel at random; and die-cast chassis.

Circle (291) on Fast Fact Card

Relay panel consolidates public safety mobile functions

The ARP 1187 relay panel from **Integrated Communications** suits public safety mobile installations for control of commonly used functions. The relay consolidates as many as eight relays on a pc board. Features include on-board surge and spike protection, flexible wiring options, on-board fusing, horn transfer capability and field-adjustable relay contacts.

Circle (313) on Fast Fact Card



Core-filled mount shaft supports heavier devices



Flex and swivel mounts from **SMC Electro-Mount** come with an optional core-filled shaft for more sturdy construction to support heavier communications equipment. The mounts come with allen screw or T-knob fasteners.

Circle (364) on Fast Fact Card

NEW NEW EAGLE SUPERLITE HEADSET (TM)

BONE VIBRATION TECHNOLOGY

Don't be fooled by in-ear products claiming to work by bone conduction-- New Eagle products are the world's only true bone vibrating headsets!



Only authentic bone vibrating headsets send and receive radio signals through your facial bones- not through your ear canal.

HIGH QUALITY two-way radio headset communication via bone vibrations.

GREATLY INCREASED USER SAFETY-- With nothing in or over either ear, user can remain alert to danger while maintaining two-way radio contact.

NO uncomfortable, unsanitary hardware inside the ear canal; nothing worn over the outer ear; no throat microphone or boom microphone.

CAN be used with in-ear hearing protectors.

LIGHTWEIGHT and comfortable--does not cause user fatigue like in-ear and over-ear products.

DOES NOT transmit background noise.

NUMEROUS headset models, options, and accessories.

THE WORLD'S FIRST bone vibration headset that works, and it works very well!

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NEW EAGLE COMMUNICATIONS

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Circle (105) on Fast Fact Card

Post your site

One of the most important ingredients in interference control is "site identification."

The day may come when an interference source is traced to your antenna site. Site interference rarely is intentional. Such interference may stem from intermodulation products and spurious emissions.

When interference happens, the fix may be vital to preserving life and property. Rapid access to your site may be crucial.

Responsible action on your part, now, before interference happens at your site, may make a critical difference.

You can help. Post your site manager's name and 24-hour phone number at the controlled access to your site. Do it now.

A public service from

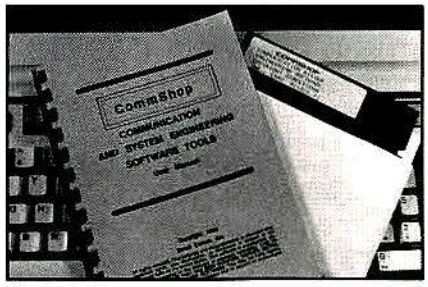
Mobile Radio Technology

Mobile data terminals contain 8-line screen

The 7100 series of mobile data terminals from **Mobile Data International** offer an eight-line by 40-character LCD screen with an adjustable viewing angle. Model 7100-11D has a dispatch keyboard with large keys. Model 7100-11FK can be configured with a user-programmable QWERTY keyboard.

Circle (305) on Fast Fact Card

Upgraded analysis software accepts English, metric input



CommShop range analysis software upgraded version 2.5 enables intermodulation predictions from a 300 frequency look-up table. The **DirectComm** enhanced software accepts English or metric distances as input and output. The range analysis software provides real world compensation to terrain classifications.

Circle (293) on Fast Fact Card

Service management system tracks contracts, profits

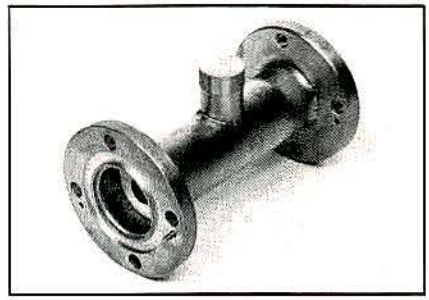
Version 6.0 of C$ervice service management system provides invoicing, accounts receivable, inventory world ticket tracking, technician productivity, maintenance contract tracking, profitability tracking and equipment service history. The **America West Communications & Electronics** software includes reports available such as period billing, sales tax collections and open work ticket list.

Circle (329) on Fast Fact Card

Transmission line protector tolerates 100kA surge current

High-powered series of lightning and EMP protection devices from **Poly-Phaser** boast rugged construction for hard transmission line protection. The protector incorporates fast turn on and high turn-off. The protector handles 100kA surge current. It comes in 7/8-inch, 1 5/8-inch and 3 1/8-inch EIA flanges.

Circle (323) on Fast Fact Card



Great Things Come In Small Packages!

When you need an economical, high-performance telephone interconnect . . . Zetron gives you a hand.



The Model 30 WORLDPATCH from Zetron offers big telephone interconnect capability in a small package. Quick, easy installation, Zetron quality performance, and simple programming combine to make the Model 30 the best value in low cost telephone interconnects. So, the next time you need a telephone interconnect for use with in-plant systems, control stations operating through repeaters, or wide area single user systems, order the Zetron Model 30.

Zetron sets the pace with the finest in communications signaling products.

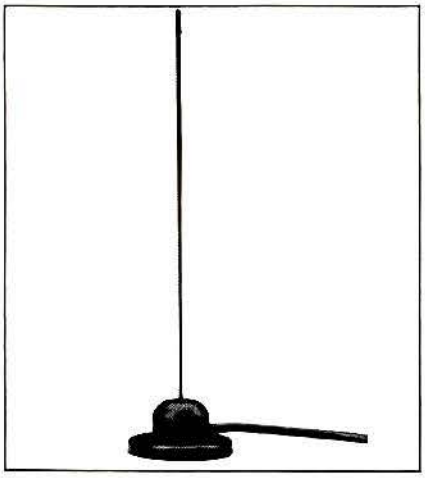
ZETRON

12335 134th Ct. N.E. Redmond WA 98052
Phone: (206) 820-6363 Fax: (206) 820-7031

Circle (90) on Fast Fact Card

Low-profile cellular antenna features magnet mount

A low-profile, magnet-mount cellular antenna is available from **Mobile Mark.** The antenna includes an enclosed phasing coil on its whip and a plastic-covered magnet case. The portable antenna is lightweight and comes in a black finish.



Circle (503) on Fast Fact Card

Mobile radio modem supports data at 4,800bps

The enhanced MRM mobile radio modem from **Dataradio** works with E. F. Johnson's trunked radio system and provides data transmission speeds to 4,800bps. The radio modem employs forward error correction.

Circle (300) on Fast Fact Card



Analog-digital scope uses display, reference memories



Model 3100D 100MHz analog-digital oscilloscope offers autoranging; 4K memories for display and reference storage; CRT readouts with cursors of voltage, time, frequency, phase and ratios for voltage; and selectable averaging from 2 bits to 256 bits. The **Leader Instruments** scope incorporates a dual time base with calibrated delayed sweep and alternate sweep; roll mode and trigger; and a universal power supply for 90Vac to 250Vac.

Circle (331) on Fast Fact Card

HIGH PERFORMANCE PRESELECTOR-PREAMP

The solution to most interference, intermod, and desense problems in repeater systems.



- 40 to 1000 Mhz tuned to your frequency
- 5 large helical resonators
- Very high rejection
- Low noise—high overload resistance
- 8 db gain—ultimate rejection >80 db
- GaAs fet option (above 200 Mhz)
- Cast aluminum enclosure
- N, BNC, and SO239 connector options

Typical rejection:
±600Khz @ 145 Mhz: 28db
±1.6 Mhz @ 220 Mhz: 40db (44db GaAs)
± 5 Mhz @ 450 Mhz: 50db (60db GaAs)
±20 Mhz @ 800 Mhz: 65db
±20 Mhz @ 950 Mhz: 70db

AUTOMATIC IDENTIFIERS

- Up to 8 EPROM programmed messages
- Adjustable audio, speed & interval timer
- "ID over voice inhibit"
- Low power option
- Modular design
- Message selection via binary input—TTL levels
- Size: 2.7 x 2.6 x 0.7"



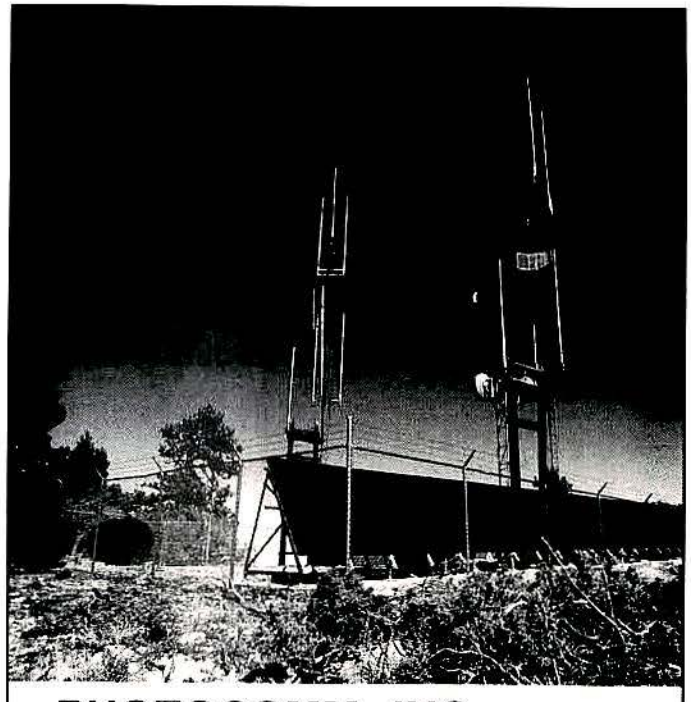
NEW Model ID-2B

The ID-2B provides required station identification without troublesome diode programming. The "ID over voice inhibit" circuitry allows for courteous operation by not allowing an ID until the next squelch closing.

ID-2B Wired/Tested $99.95 **ID-2B-LP Low Power $109.95**

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Circle (92) on Fast Fact Card

Unit transmits messages to fax, paging systems



Pagentry telecommunications device from **Real Time Strategies** transmits alphanumeric messages to paging systems and facsimile machines. The unit offers storage of pager access codes, paging terminal telephone number, fax unit telephone number and general information. Other features include a five-function calculator; group calling capability; time-of-day clock and calendar; canned alphanumeric messages; and an alarm clock and reminder capabilities.

Circle (203) on Fast Fact Card

Two modules enhance billing, management software

Carrier management software for billing, inventory and switch terminal interfaces of mobile communications carriers from **Subscriber Computing** includes fax and Touch-Tone modules. The FaxMax module enables a carrier to send monthly invoices to accounts automatically via fax. The TouchTalk module allows customer to use a Touch-Tone telephone to access account information on a 24-hour-a-day basis.

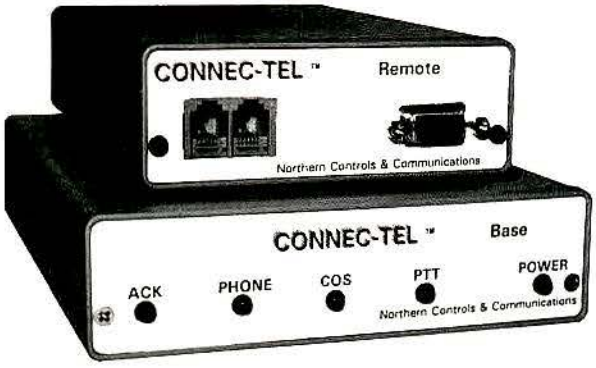
Circle (318) on Fast Fact Card

UHF mobiles permit programmable RF output

Model 70-1595 under-dash mobile and model 70-1695 remote-mount mobile cover 406MHz to 430MHz or 450MHz to 470MHz without retuning. The **Midland LMR** mobiles offer programmable RF output from 50W to 100W. The units feature a 22-channel capability, which is expandable to 99 channels with a plug-in module. Other features include dual-priority fast-channel scan, and CTCSS and DCS with standard codes, programmable by channel. The mobiles have built-in data ports and have die-cast chassis. They meet military specs 810C and D.



Circle (290) on Fast Fact Card



CONNEC-TEL ™

Remote: Provides a standard RJ-11 input/output to a full duplex radio allowing the use of standard telephone equipment, FAX machines, answering machines, modems and cordless telephones on the radio system. The Remote can operate on any multi-user interconnect system with DTMF signaling, directly with another Remote for direct ring radio links or with the BASE.

Base: Provides a standard telephone interconnect to remote or mobile locations where phone lines are not available. the unit operates as a line extender for Rural applications or it can be programmed to selectively call any of three individual REMOTES.

FEATURE-PACKED

REMOTE : *$329.00 Dealer net*

- ✓ ADVANCED DTMF DECODER / ENCODER (Std.)
- ✓ OPTION "C" CTCSS DECODER ALL 38 TONES
- ✓ OPTION "E" EXTERNAL I/O DECODE & GE TRUNKING
- ✓ OVER-THE-AIR DISABLE / ENABLE WITH TRANSPOND
- ✓ "MONITOR LOCK"®
- ✓ CTCSS ENCODE ALL 38 TONES
- ✓ AUTO DTMF ANI CONNECT / DISCONNECT (8 DIGIT)
- ✓ INTERNAL RING GENERATOR & SUPERVISION TONES
- ✓ SELF TEST FUNCTIONS & 1000 HTZ. TONE GENERATOR
- ✓ OPERATES ALL STANDARD TELEPHONE EQUIPMENT
- ✓ 13 PROGRAMMABLE FUNCTIONS / NON VOLATILE MEMORY
- ✓ LOW POWER...LESS THAN 45 MA IN STANDBY

BASE: *$349.00 Dealer net*

- ✓ PROGRAMMABLE CWID & INTERVAL TIMER
- ✓ EASY INTERFACE & SETUP
- ✓ FULL OR HALF DUPLEX
- ✓ ANI VALIDATION FOR ACCESS
- ✓ CTCSS ENCODE PER USER
- ✓ DTMF OR CTCSS SELECTIVE SIGNALING
- ✓ LINE EXTENDER OR AUTO CALL MODE #0
- ✓ AUTO ANSWER WITH SELECTIVE CALL OUT MODE #1
- ✓ REGENERATED DTMF OR PULSE DIALING
- ✓ SELF TEST & INTERNAL 1000 HTZ TONE GENERATOR
- ✓ 16 PROGRAMMABLE FUNCTIONS
- ✓ 3 USER CAPABILITY IN MODE #1

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Circle (93) on Fast Fact Card

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Circle (94) on Fast Fact Card

New products

On-site paging systems come in two versions

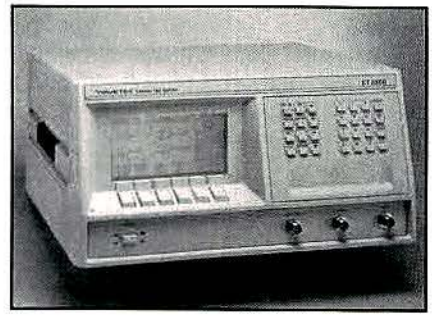


Maxcall on-site paging systems from **Maxon Paging Products** include two types of systems: multiformat paging systems and POCSAG-only paging systems. The multiformat paging systems incorporate software for the most common paging formats and feature talkback paging, telephone interface, 1,000-pager capability and transmitter options from 2W to 100W. The POCSAG-only system for on-site communications can be configured according to custom specifications to handle paging needs.

Circle (310) on Fast Fact Card

Cellular test set uses icon-driven menus

The CT-3500 cellular test system from **CT Systems/Wavetek** features a backlit LCD and icon-driven menus and prompts. The system performs a complete diagnostic test on any cellular telephone system, from the handset to the antenna. It includes auto registration, antenna VSWR testing, manual mode and eight-test storage capability. The tester includes a built-in parallel port for printer attachment.



Circle (510) on Fast Fact Card

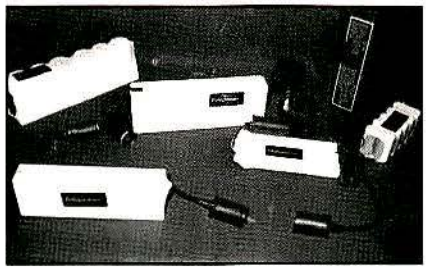
Flex mounts include 8-, 10-, 13-inch lengths

The vinyl clad flex mounts from **SMC Electro-Mount** feature flexible shafts covered with a black vinyl coating. The mounts come with a standard "amps" top plate and 2½ round and cupped base plate. The mounts are available in 8-, 10- and 13-inch lengths.



Circle (365) on Fast Fact Card

'Bag-phone' battery kits include charger, adapter



Telepower "bag-phone" battery kits include battery, charger and adapter parts, if necessary, for use with cellular telephones. The **JaBro Batteries** kits available include two nickel-cadmium kits at 1,500mAh and four sealed lead-acid kits ranging from 2,200mAh to 2,500mAh.

Circle (370) on Fast Fact Card

Dc-remote console handles 3 base stations

Model C-534 dc-remote console from **Vega** controls as many as three independent base stations over two-wire, four-wire or two-wire earth-ground-return metallic lines. The unit's summed-audio position allows listening to all remote base-station receivers simultaneously. The console operates with parallel C-534 consoles or with compatible single-line dc consoles.

Circle (342) on Fast Fact Card





The Most Important New Test Equipment You'll Buy Comes From DCT

DCT's new SNA scalar network analyzers are everything you asked for in test equipment.

- Portable. The first field worthy, hand-held units.
- Versatile. Analyze antenna, connector, T-line, filter, amplifier and receiver performance.
- Fast, accurate.
- Lightweight and rechargeable.
- Money makers. Cut callbacks.

Spectrum-specific models save you money.

- SNA 30 for 1.5 to 60 MHz.
- SNA 300 for 10 to 520 MHz.
- SNA 900 for 700 to 1300 MHz.

The perfect tool for M & I testing.

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"We're Measurement Magic"

Circle (89) on Fast Fact Card

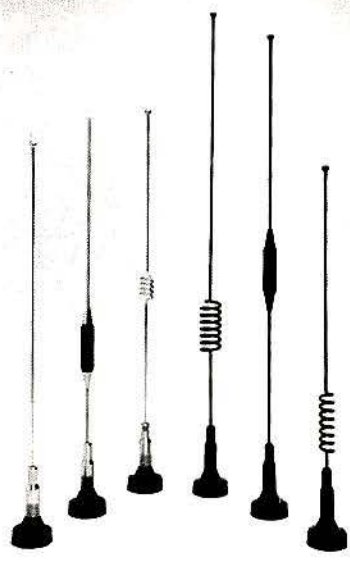
COMTELCO *INDUSTRIES, INC.*

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Classic Series

UHF/VHF Antennas

- Rugged Design
- Spring Loaded Contact
- Premium Quality
- Made in the USA



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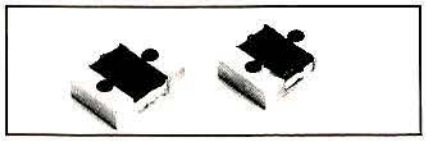
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Comtelco Industries, Inc.
501 Mitchell Rd., Glendale Hts., Illinois 60139

Circle (88) on Fast Fact Card

Attenuators, terminations operate from dc to 4GHz

Thick film microstrip attenuators and terminations operate from dc to 4GHz, depending on package selected. The **JFW Industries** attenuators and terminations use a positive thermal coefficient that prevents thermal runaway.



Circle (336) on Fast Fact Card

Wideband mobile requires no programmer

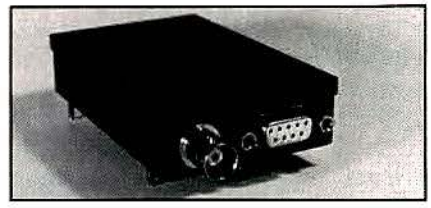
Model MD450 40-channel 30W wideband mobile from **Tad Radio** covers the 403MHz-to-470MHz band. The radio does not require a special programmer. Transmitter bandwidth is 30MHz, and the receiver bandwidth is 70MHz.

Circle (288) on Fast Fact Card

Data, telemetry radio offers fast attack time

Model KS-900 UHF transceiver from **Tekk** features a fast attack time, 2W RF power and a 0.35V receiver. The data and telemetry radio operates as high as 9,600 baud and is about the size of a credit card.

Circle (289) on Fast Fact Card



Remote for duplex radio enables phone, fax use

The Connec-Tel remote from **Northern Controls & Communications** provides a standard RJ-11 input and output to a full duplex radio. The connection enables use of standard telephone equipment, fax machines, modems and cordless telephones on interconnected radio systems. The remote features DTMF, CTCSS or external decode; CTCSS encode; automatic ANI; on-board ring generator and 1,000Hz tone generator; and 13 programmable functions.

Circle (201) on Fast Fact Card



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- Talking Time Clock repeats time/date on optional Time Track
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Circle (96) on Fast Fact Card

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Circle (97) on Fast Fact Card

Video teaches dispatchers communications techniques

A video dispatcher training program from **Public Safety Communications Specialists** focuses on effective communications techniques for dispatchers. The 90-minute video includes information gathering and call processing procedures.

Circle (325) on Fast Fact Card

Radial ground system protects in-line ac power

The PRM-25E chemical radial ground system attaches to a **PolyPhaser** chemical PolyRod container for in-line ac power protection. Each unit is equipped with three 25-foot perforated 1/4-inch copper tubings and one distribution valve.

Circle (322) on Fast Fact Card

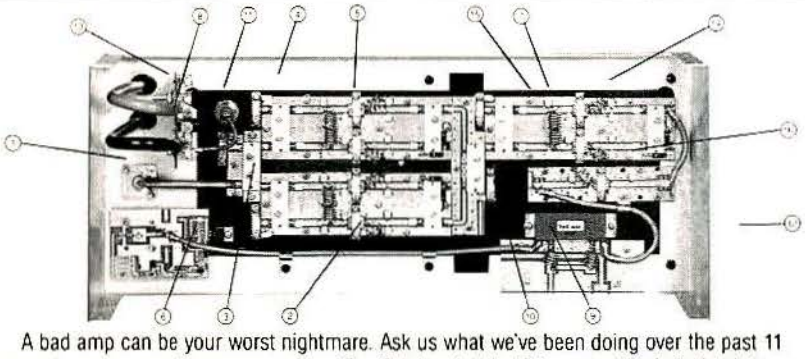
Toroid transformer tester offers ±0.2% accuracy

Model 3500A toroid transformer tester handles small-signal transformers for communications with core inside diameters (IDs) as small as 0.060 inch, as well as larger transformers for power conversion and transmission with IDs as high as 8 inches. The **Atlantic Magnetics** tester eliminates human error, has a 15-second test and offers ±0.2% accuracy.

Circle (497) on Fast Fact Card



16 REASONS TO BUY OUR RF AMPLIFIERS



A bad amp can be your worst nightmare. Ask us what we've been doing over the past 11 years to make your dreams come true. Our Catalog details 16 important technical points you should know before you make a commitment to an RF amplifier supplier. Our product line includes:

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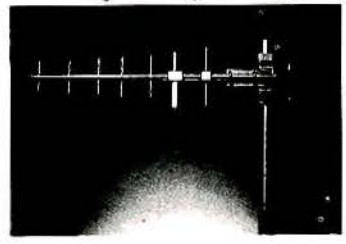
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Circle (98) on Fast Fact Card

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DB498 and DB499 heavy duty Yagis for 806-960 MHz

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Range: 806-960 MHz
Bandwidth: 62-72 MHz
Gain: DB498 = 9 dB
DB499 = 10 dB
Power: DB498 = 100 watts
DB499 = 150 watts
Front-to-Back Ratio:
DB498 = 18 dB
DB499 = 20 dB
Polarization:
DB498 = vertical
DB499 = horizontal or vertical

An additional 3 dB gain can be achieved by using dual antennas with appropriate harness.

A unique mounting arrangement permits rapid azimuth orientation and, with the DB499, either vertical or horizontal polarization.

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Circle (99) on Fast Fact Card

Remote monitoring system sends alert message to pager

The Pagnow remote monitoring system automatically alerts a pager with a message of a problem and its location. Available from **Compuquest,** the unit monitors buildings and entrances; smoke, fire or water alarms; equipment; restricted areas; and communications facilities. The monitoring system has an internal rechargeable battery that provides backup for as many as six hours when external power fails.

Circle (317) on Fast Fact Card



Echo canceler deters cellular, satellite resound

The ED-6000 digital echo canceler from **Coherent Communications** works with cellular and satellite communications. The unit cancels echo without barrel-effect even when conversation is simultaneous.

Circle (295) on Fast Fact Card

Low-loss transmit filters suppress TX noise by 50dB

Two low-loss transmit filters for cellular rural service area markets provide TX noise suppression of at least 50dB at 849MHz. The **Celwave** filters accommodate later expansion of spectrum channels.

Circle (312) on Fast Fact Card

Mobile antenna incorporates four-band performance

The Spectra mobile antenna covers four bands in a single antenna. Bands include lowband VHF, highband VHF, UHF and 800MHz to 1,000MHz. The **Austin Antenna** product handles 100W power.

Circle (296) on Fast Fact Card

Improved radio houses track tuning, CTCSS

The RH256NB improved radio from **Relm Communications** incorporates larger volume and squelch control knobs, track tuning to cover an expanded 12MHz range without retuning, surface-mount devices and built-in CTCSS. The 16-channel radio includes scan, scan delay, priority channel, time-out timer, low RF power indicator, off-hook scan, power up on channel 1 and transmit carrier turn-off delay.

Circle (320) on Fast Fact Card

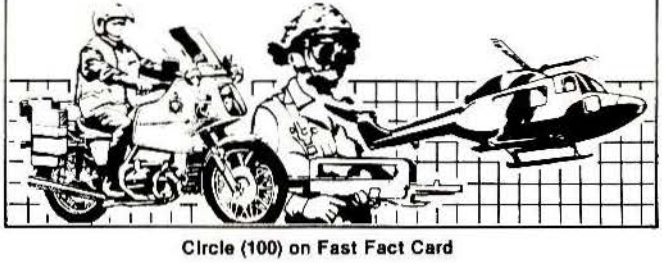
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SONIC Helmet Kits fit existing helmets with no modifications required and interface with today's most popular radios.



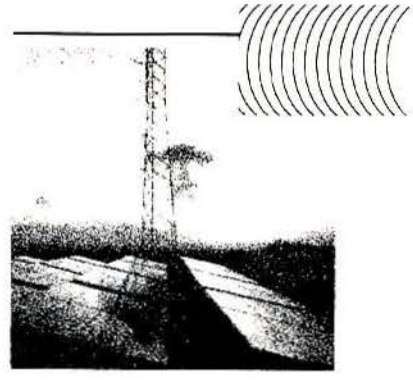
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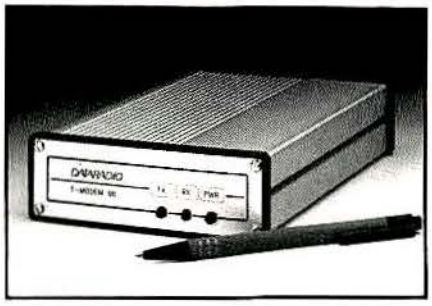
Siemens Solar Industries

Circle (101) on Fast Fact Card

Data modem operates at speeds to 9,600bps

The T-Modem 96 data and telemetry modem operates at speeds of 1,200bps, 2,400bps, 4,800bps and 9,600bps. The **Dataradio** modem is user-adjustable via a built-in switch. The unit includes LED indicators for power, transmit and received data. It operates from a 12Vdc power source and is protected from over voltage or reverse polarity.

Circle (321) on Fast Fact Card



Plug-in device enhances portable battery life



The NEC300 battery saver for the NEC P300 portable cellular telephone attaches to the phone in place of the regular battery. The battery saver unit from **Ora Electronics** plugs into a vehicle's cigarette lighter for power from the vehicle's battery. It increases the portable battery's talk and standby time.

Circle (259) on Fast Fact Card

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4 CHANNEL **$149.00**



Space Age Technology and Reliability, Top Quality Engineering, Rugged All Weather Construction

Price Includes:
6" Antenna, Wall Charger, Battery, Soft Case, Belt-Clip, One Operating Frequency Installed

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SYNTHESIZED

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8 CHANNEL **$189.00***



Our State-of-the-Art synthesized design makes extensive use of surface mount technology to reduce the size of components and eliminate excessive heat build-up. This combination produces a radio with extremely high frequency capability and minimal deviation characteristics.

Price Includes:
Hi–Low Power Switch, 6" Antenna, Soft Case, Wall Charger, Wrist Strap and 500 MAH Slide-Off Battery.

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HUTTON

Circle (103) on Fast Fact Card

Literature

Report studies cellular market

"Cellular Subscribers and Forecasts" is **Herschel Shosteck Associates** quarterly report based on its December 1989 cellular market survey.

Circle (511) on Fast Fact Card

Study guide prepares technicians for NABER exam

The updated study guide for the NABER technician certification exam features a full-length sample exam and test question explanations. Joe Bartelme of the Mobile Training Institute wrote the explanations. Step-by-step instructions on how to register for the exam; FCC rules and regulations; and soldering, hand tool use and installation are included. "NABER Technician Certification: Study Guide and Sample Exam" is published by the **National Association of Business and Educational Radio.**

Circle (400) on Fast Fact Card

Brochure describes cellular cases

Quick-disconnect swivel attachment, bungi-cord and t-strap are available with **Bee Electronics'** heavy-duty cellular cases. Leather cases fit DiamondTel, Mitsubishi, Motorola, Panasonic, NEC, Uniden, Technophone, Audiovox, NovAtel and Nokia-Mobira phones.

Circle (403) on Fast Fact Card

Catalog features signaling, scrambling equipment

Voice scrambling products; ANI; status; and location equipment including CAD systems, decoder displays and ANI encoders are listed in **Midian Electronics'** tone signaling and voice scrambling catalog. Tone signaling products include encoders, decoders and ANI formats including DTMF, CTCSS, DCS, burst, IMTS, IPTS, two tone, five tone, GE-Star and Midian Zap digital formats.

Circle (407) on Fast Fact Card

Brochure features towers, shelters

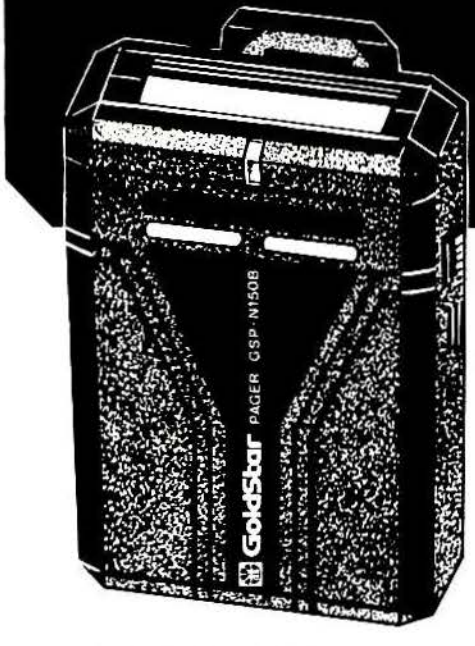
Communications towers, tower-related services, communications equipment buildings, mobile communications equipment buildings and standby power systems are described in **FWT's** corporate brochure.

Circle (404) on Fast Fact Card

Catalog discusses lightning protection

Concepts, advantages and applications of static dissipation systems for lightning protection are discussed in **Lightning Prevention Systems'** catalog. Grounding techniques and products are included in the publication.

Circle (401) on Fast Fact Card



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Circle (104) on Fast Fact Card

U.S. manufacturers top list of mobile radio leaders

U.S. companies are considered the top mobile radio manufacturers, according to respondents to the September 1990 "What Do You Think?" questionnaire. The manufacturers selected as the four industry leaders are Motorola, Schaumburg, IL; General Electric, Lynchburg, VA; E. F. Johnson, Waseca, MN; and Midland LMR, Kansas City, MO.

The readers are active purchasers of mobiles, with 87.9% reporting they have bought mobiles in the last 12 months. VHF highband mobiles are the most popular type used, survey respondents report. Statistics include:

TYPES OF MOBILES USED	%
VHF highband	80.3%
UHF	65.2%
VHF lowband	45.5%
800MHz	34.8%
HFSSB	7.6%
ACSSB	3.0%

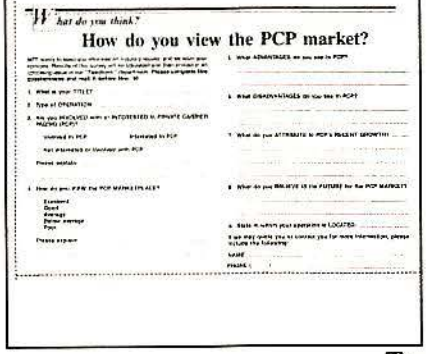
Readers list improvements they desire in mobiles. They include:

- "Eliminate the need for an IBM-compatible computer to program and perform adjustments on radios. Keep all adjustments inside the radio and keep them manually adjustable."
- "Make the controls user-friendly on the multichannel scan radios."
- "Increase channel flexibility and multiband capability in one radio."
- "Have less 'dodads' for situations where they are confusing."
- "Manufacture more dualband portables."
- "Include smaller packages, eliminate wiring harnesses by using fiber optic cables."
- "Provide service manuals with an emphasis on repair to component level."
- "Have built-in DTMF or two-tone decode-encode and more UHF full duplex."
- "I would like to see more solder on all connections."
- "Would rather see some cooperation from some automakers—plastic dashes—ugh."
- "Smaller size and faster channel scan."
- " More serviceable radios with less computer technology and better quality hand mics."
- "Louder speakers and bigger displays on knobs."
- "It would be nice to see a larger selection of PC-programmable radios."

Technological improvements respondents propose include:

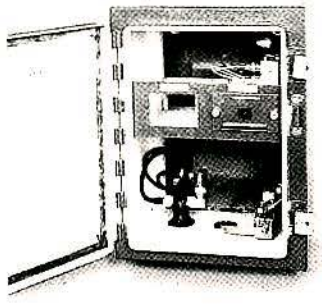
- "Complete and total elimination of surface-mount components. Much improvement is needed in the quality of connecting plugs."
- "More telephone and radio integration."
- "More exploration of ACSSB and digital techniques."
- "More power output on smaller units—better use of networking—linking stations together."
- "The manufacturers need to go on to where the whole radio is modular so we don't have to service components on some parts and board level on others. Being in transitions like we are is a mess."

Be sure to fill out this month's "What Do You Think?" questionnaire on page 129 so your responses can be included in a future "Feedback" column.



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DB8900 Series Tower Top Amps 400/800 MHz

Decibel's high gain, low noise pre-amplifier — placed at the antenna terminal — overcomes noise and Rx degrading caused by transmission line loss.

Preceded by a flat-passband preselector filter, the pre-amp extends the "talk back" range of a low power Tx in 456-470, 806-824 or 896-901 MHz ranges.

The 400 MHz unit can handle 800 MHz signals, unamplified, in a common transmission line — and vice versa.

Specifications

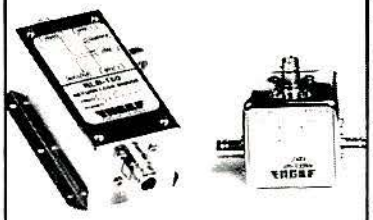
Gain: 20 dB
Noise figure: 3.5 dB
3rd Order intercept point: ± 35 dBm
Power: 115 VAC

The amp is tuned and shipped in a weatherproof enclosure with a rack-mountable power supply.

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- Rugged construction
- .04 Mhz to 1.0 GHz

Return Loss Bridges

EAGLE Return Loss Bridges allow high performance SWR measurements from 40 KHz to 1000 MHz. The RLB-150 series bridges include a precision internal reference. The RF measurement port (bridge output) allows use with a spectrum analyzer/tracking generator for swept VSWR measurements. Use with a spectrum analyzer also allows antenna measurements at very low levels (0 dBm) thus preventing interference to other users. Can also be used with network analyzers for phase and group delay measurements. Five watt power rating, unmatched in the industry, provides the ability to measure the dynamic return loss of a power amplifier's output. Bridge directivity is typically 45 dB. Rugged nickel plated brass enclosures assure excellent durability and shielding. Units are available from stock in the following ranges:

RLB-150B1	40 KHz to 150 MHz	$259.00 ea
RLB-150N3	5 MHz to 1000 MHz	$329.00 ea

Request application note, "High Performance VSWR Measurements", which discusses the use and applications of return loss bridges. It's free for the asking.

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Unlike any other lightning protection device for coaxial transmission lines, I.C.E.'s Model 300 series requires no predetermined voltage to develop between conductors before voltage suppression begins. Units are constant drain, capacitor-blocked, non-DC passive, and each relies on a heavy discharge inductor paralleled with a ceramic gas-discharge assembly to provide a lightning-fast trap system for induced voltages.

Virtually indestructible, 300 series arrestors are built in 1/8" thick standard chassis enclosures with dual stainless steel mounting/grounding screws.

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SPECIFICATIONS

Attack time	Zero to 10ns, depending on induced waveform.
Surge current	8/20 us, 20,000 amps
Operating Temp.	-65 to 125 Celsius
Discharge Inductor	Toroidal, Insulated
Back-EMF GDU	600-1000V, ceramic body construction, G.I. Clare
VSWR	Less than 1.1:1 over rated spectrum
Insertion loss	Less than .1db
Impedance	50-75 ohms
Hardware	18-8 stainless hardware 8-32 stainless steel ground lug, 1.8" thick 5052-H32 case, 6-32 mounting hardware
Finish	Natural aluminum
DC resistance across	47K to 250K ohms, resistive
Capacitive effects	Less than 1pf
GDU specs.	Meets REA PE-80 IEEE 587 CCITT K12
Environmental	Recommended for indoor service at input bulkhead to station's grounding system. May be used outdoors if protected from direct rain exposure
Warranty	One year standard

MODELS, PRICES
HF-VHF (1.5 TO 225 MHZ)

MODEL 301 U	300W, SO239s	$29.95
MODEL 301 N	300W, N CONNS	$31.95
MODEL 301 B	300W, BNC	$29.95
MODEL 301 R	300W, RCA PIN	$29.95
MODEL 303 U	5KWPEP, SO239s	$34.95
MODEL 303 N	5KWPEP, N CONNS	$36.95

CATV, 75 OHMS

MODEL 310, RCV.ONLY, "F" CONNS.		$26.95

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Circle (108) on Fast Fact Card

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Appointments at Tessco, Hunt Valley, MD:

Rocco Baldasare leaves The Personal Marketing Company, Houston, as director of market development and joins Tessco as manager of the user market.

JoAnn G. Connelly advances from manager of customer coordination to director of customer coordination for Tessco.

Anne-Marie Rubb exits Walpert, Smullian and Blumenthal, P.A., Towson, MD, as client administrator to join Tessco as manager of customer transactions.

Janet C. Swartz leaves Baltimore Federal Financial, F.S.A., Baltimore, as marketing director to become Tessco's advertising manager.

Appointments at Maxrad, Elk Grove, IL, include:

Thomas R. Ude leaves Fujitsu Ten, Torrance, CA, as PBX field sales manager to join Maxrad as director of marketing.

Dann R. Scheri advances from plant manager and assistant secretary to vice president of manufacturing operations.

Anne J. Smolak adds assistant treasurer to her responsibilities of office manager.

Don M. Ringler advances from vice president to executive vice president and chief executive officer.

Appointments at Unipage, DeSoto, TX:

Ken Lawler advances from national sales manager to vice president of sales for Unipage.

Ed F. Robertson departs Glenayre, Duluth, GA, as director of international sales to join Unipage as area sales manager.

Fred Gonzales leaves Communication Repair Center, Dallas, as communications consultant to join Unipage as technical field engineer.

Lupe Rodriguez exits MW International, Dallas, as manufacturing engineer to become manufacturing engineer for Unipage.

Kevin Fiveash departs Communications Groups International, Ol'Miss, TX, as a systems engineer to join Unipage as field service engineer.

Louis I. Guion leaves Communications Industries, Dallas, as vice president and general manager to join Unipage as controller.

Laurie A. Bado advances from assistant controller to vice president of control for Drive Phone, Paramus, NJ.

Calendar

April

14-17—Associated Public-Safety Communications Officers North Central Regional Meeting, Ft. Des Moines Hotel, Des Moines, IA. Contact: Marion Wissler, 515-281-4584.

24-26—Mobile Communications North America, Toronto Convention Center, Toronto, Canada. Sponsored by Telocator and Radiocomm. Contact: 800-422-4862.

May

9-12—National Association of Business and Educational Radio Annual Meeting, Westin O'Hare, Chicago. Contact: 800-759-0300.

19-22—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Sheraton West Port Inn, Maryland Heights (St. Louis), MO. Contact: Jay Underdown, 314-946-9980.

20-24—Associated Public-Safety Communications Officers East Coast Regional Meeting, Wilmington Hilton, Wilmington, NC. Contact: Mary Garrett, 919-343-3647.

June

25-27—Utilities Telecommunications Council 43rd Annual Meeting, Hyatt Regency Ohio Center, Columbus, OH. Contact: Rita Clark, 301-621-7802.

July

7-10—Forestry-Conservation Communications Association, Great Smokies Hilton, Asheville, NC. Contact: Don Pfohl, 602-644-3166.

August

5-10—National Professional Electronics Convention, Nugget Hotel, Sparks, NV. The International Society of Certified Electronics Technicians (ISCET) will also meet. Contact: NESDA/ISCET/NPEC, 817-921-9061.

12-15—Associated Public-Safety Communications Officers 57th National Conference, Tulsa, OK. Contact: 800-824-1850.

September

19-21—Mobilexpo & Cellular Showcase, Orange County Convention Center/Civic Center, Orlando, FL. Contact: 303-220-0600.

21-25—International Association of Fire Chiefs Annual Meeting, Toronto. Contact: 202-833-3420.

25-28—Special Industrial Radio Service Association Annual Meeting, Hyatt Lake Tahoe, Incline, NV. Contact: Barbara J. Levermann, 703-528-5115.

October

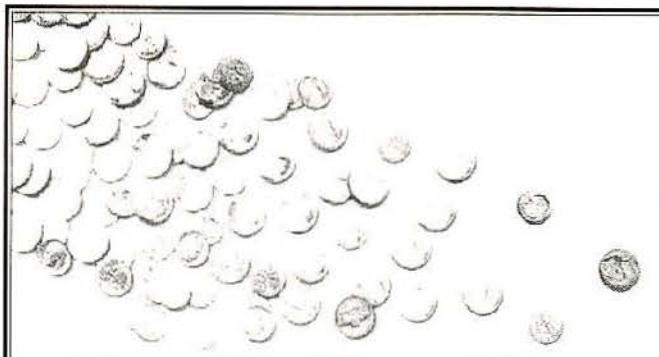
5-10—International Association of Chiefs of Police Annual Meeting, Minneapolis. Contact: 703-243-6500.

21-24—Mobile Communications Marketplace, Anaheim Convention Center, Anaheim, CA. Contact: Telocator, 800-422-4862.

November

14-17—Communications Marketing Conference, Embassy Suites Hotel, Denver. Contact: Gene Johnson, Vega Signaling, 818-442-0782.

22—Radio Club of America Annual Meeting and Awards Banquet, New York Athletic Club, New York. Contact: 201-246-7271.



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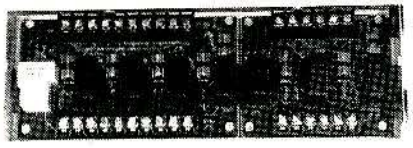
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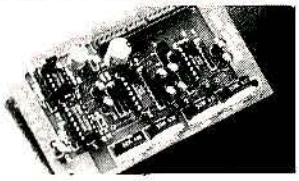
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Mot 800 MHz "Mostar/Traxar" trnkd, **tech spl.** w/o PA	75
Mot 800 MHz "Micor" 35w trnkd/conv (T45RTA)	200
Mot 800 MHz "Maxar-80" 10w conv. DPL (D25TSA)	200
GE 800 MHz "TMX8415" 15w trnkd	300
GE 800 MHz "Classic I" 10w, trnkd w/handset, not tested	75
GE 800 MHz "Classic I" 10w, trnkd w/rem. accy (MIA47/MID47)	150
GE 800 MHz "Century II" 10w conv. (CE35BBU)	75
GE 800 MHz "MVP" 10w conv. (CT45.92)	150
EFJ 800 MHz 8850/8800/8700 series, trnkd	call
Kokusai 800 MHz MX8675 trnkd w/GL2035 hd, 1 ea.	200
Regency WS30200B w/GL2035 hd, 4 ea.	200
Mot 450 MHz "Micor" 75w, PL/DPL (T54RTA)	250
Mot 450 MHz as above w/wide space xmtr	275
Mot 450 MHz "Micor" 25/45w, 25w/W.S.T. PL (T34/44RTA)	200
Mot 450 MHz "Mitrek" 75/100w, PL/DPL (T64/74JJA)	call
Mot 450 MHz "Mitrek" 30/50w, PL/DPL (T34/44JJA)	300/350
Mot 450 MHz "Mocom 70, 50, PL/DPL (T44 470 MHz also)	200/150
Mot 450 MHz "Mocom 70" 25w, PL (U44BBN)	125
Mot 450 MHz "Mostar" 20/30w synth 2.8/16F (D34/44TLA)	250/325
Mot "Maxar 80" "Maxar" "Maxar 50"	call
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Mot 150 MHz "Micor" 110w, 4T8R/wide space XMT/RCV (T83RTA)	300
Mot 150 MHz "Micor" 60w, c/sq PL (T53RTN)	200
Mot 150 MHz "Mocom 70" 100w, PL, 14F (T73BBA)	250
Mot 150 MHz "M 70" 60/45w, c/sq (T53/43BBA) No accy	75
Mot 150 MHz "Mitrek" 60/40w, PL/DPL (T53/43JJA)	350/250
Mot 150 MHz "Maxar80" 50/25w, PL/DPL (D43/33TSA)	250/200
Mot 146-147 MHz, MCX.100, 30w, w/ or w/o scan Rem/Loc	350/300
Mot 146-147 MHz "MCX.90" 30w, 16f, synth	300

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Mot 42-50 MHz "Micor" 100w, PL (T71RTN)	250
Mot 42-50 MHz "Mocom 709" 100w, PL (T71BBA)	250
Mot 36-42 MHz "Maxar" 25w, 2f, c/sq/PL (D31TRA)	160/200
Mot 30-36 MHz "Maxar80" 55w, PL EXT (D51TSA)	250
GE "MVP" 800 MHz, 10w conv. CG	150
GE 450 MHz "Exec II" 75w, c/sq, 4f (RT65)	250
GE "Phx-S" 25w w/o accy	200
GE 150 MHz "Master II" 100w, CG (MX76KF)	250
GE 150 MHz "Master II" 100w, CG "E" series w/W.S.T	275
GE 150 MHz "Exec II" 100w, 4f, c/sq (SX76FFS)	200
GE 150 MHz "Phx-S" 40w, 16f, w/o scan (NSA06)	399
GE 150 MHz "Phx" 40w, XTAL (M3A01) w/o accy	100
GE 150 MHz "MVP" 25w, 1f, c/scg CG (CT56)	150/175
GE 42-50 MHz "Exec II" 100w, c/s (RT74AAS)	200
GE 42-50 MHz "Master II" 50w, cg, NB (RT64AAW)	100
GE 42-50 MHz "Master II" 100w, cg (MC74AAU)	250
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Mot "Mocom 70" DPL enc/dec (TLN5817)	50
Mot "Micor" PL decoder (TLN4294/TRN8259)	20
Mot "Micor" PL encoder, later (TLN5731/32)	15
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Mot "Mitrek" DPL enc/dec (HLN4011)	40
Mot "Maxar" PL enc/dec (TRN6177)	40
Mot "Maxar" DPL enc/dec (TRN6207)	30
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GE "PE" CG enc/dec (19C321Q17G1)	20
GE "Master II" CG enc/dec (19D417261G1)	30
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GE "Master II" Time out timer (19C3W134G1)	10
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Mot "Comanche" 3db w/PL259 (RRA5304)	new 20
Mot 450 MHz 5db trnk mnt (TAE6062)	new 25
Mot 450 MHz 5db trnk lip mnt (HAE4023)	new 25
Mot 450 MHz 5db omni mnt w/PL259 (RAE4014/RRA5225)	new 20
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Federal "PA1000" tested ok, no accy	60
Federal "PA20" tested ok, no accy	50
Federal model CPA100A, amplifier only - not tested	5
Unitrol 280/380/480 remote w/model 80 PA only	35
Unitrol series 800, w/brkt only	35
S&W "Magnum IV" no accy	50
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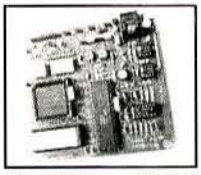
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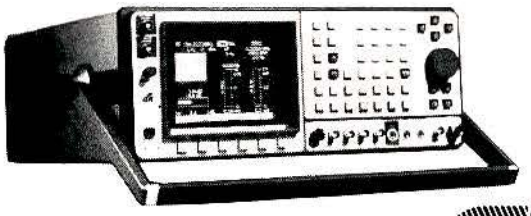
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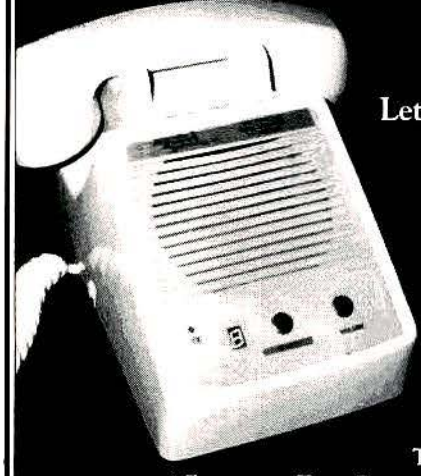
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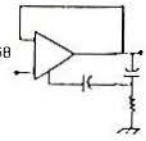
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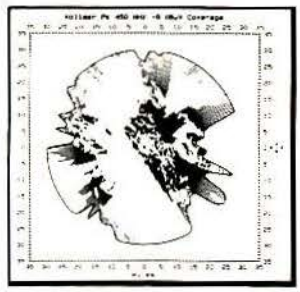
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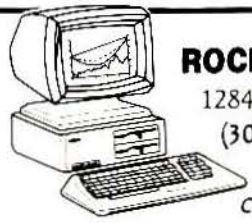
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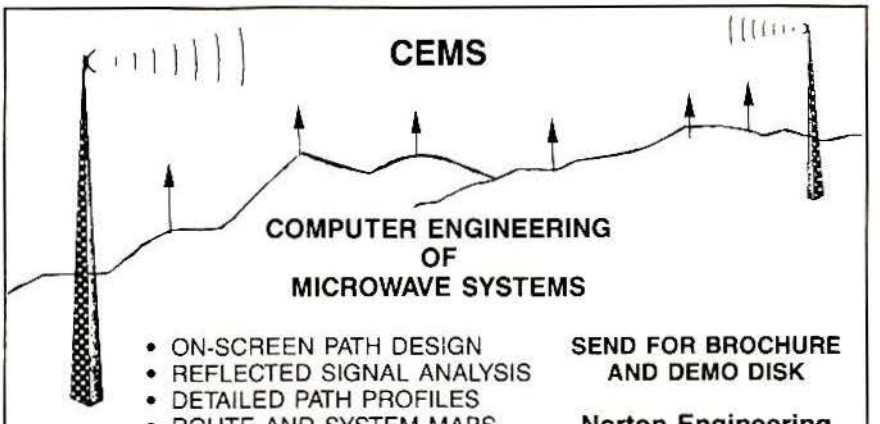
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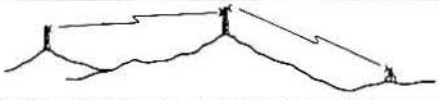
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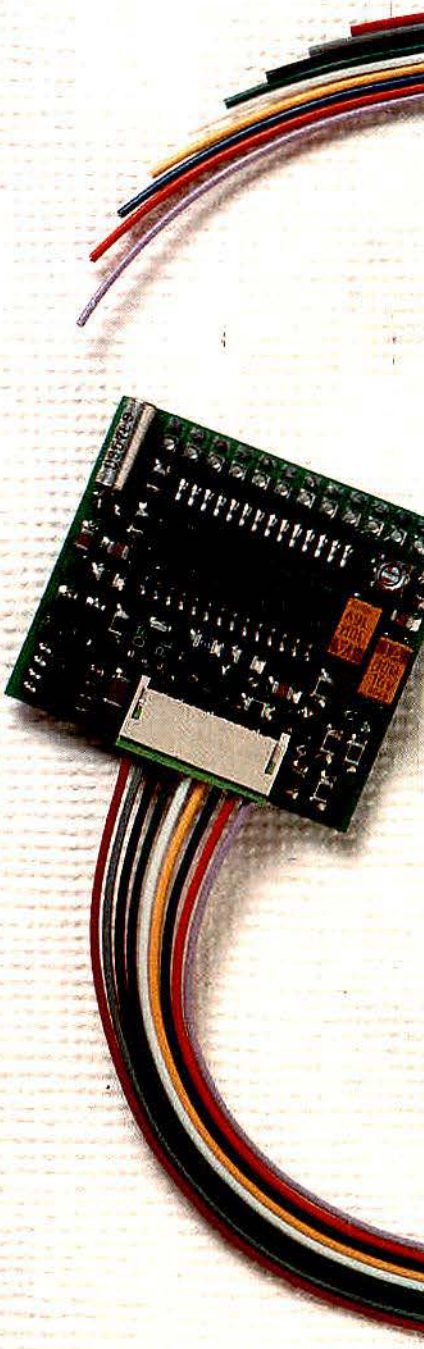
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- Totally immune to RF
- Uses crystal controlled CMOS microprocessor for low voltage operation
- Three pole high pass filter included to remove tone from received audio
- All connections made with microminiature plug and socket with color coded wires attached
- Double sided tape supplied for quick mounting
- All industry standard digital codes are field programmable with simple PCB jumpers
- All 512 octal codes can be programmed
- Simple field programming of both transmit and receive data polarity
- Operates over full temperature range of -30°C to +65°C
- Easy hookup with external diodes for multi-code encode or decode
- Powered by a very low voltage of 6vdc to 20vdc @ 8ma.
- Full one year warranty when returned to the factory for repair
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Decode

- Sensitivity better than 15mv
- A signal to noise ratio of better than 4db Sinad reliably operates decoder
- Decode time is 171ms (one word length)
- Decode input Z is 60k, AC coupled, for easy discriminator hookup
- Open collector transistor muting can be programmed for ground to enable or ground to mute
- Automatic hookswitch monitoring when mike is removed from hanger
- Automatic squelch tail elimination by turn off code detection

Encode

- Golay 23 bit digital word sent at 134.4 Hz data rate
- Turn off code of 134.4 Hz sine wave for 180ms sent to eliminate receiver squelch tail
- Output Z is 2.2k, AC coupled, and adjustable from 0-3v
- Open collector high current transistor for P.T.T. keying
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